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REVEGETATION AUGMENTATION BY REUSE OF TREATED ACTIVE SURFACE MINE DRAINAGE: A FEASIBILITY STUDY

Frank J. Zaval, et al

NUS Corporation

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Revegetation Augmentation by Reuse of Treated Active Surface Mine Drainage

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Determination of project feasibility was based upon the performance and results of the following investigative measures: waters of receiving streams and pit discharges were analyzed and evaluated for treatment; regraded spoil banks were sampled and analyzed with respect to treatment and nutrient requirements necessary for vegetative survival; and weir structures, monitor enclosures and instruments were evaluated and selected for application in unattended installations.

Based upon the analyses performed, a flow diagram of a suitable limestone neutralization facility was developed.

Four irrigation techniques were evaluated before a high pressure spray system was selected as the most practical means of delivering the treated drainage. Pertinent cost estimates were developed for the construction, installation and operation of the entire system at the selected demonstration site.

This report was submitted in fulfillment of Project Number 14010 HNS under the partial sponsorship of the Office of Research and Monitoring, Environmental Protection Agency.

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A FEASIBILITY STUDY

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ABSTRACT

The objective of this study was to determine the feasibility of conducting a full-scale demonstration project on the use of neutralized acid mine drainage to irrigate new vegetative cover on regraded spoil banks. Two active surface mine sites in the Commonwealth of Kentucky were thoroughly evaluated for this purpose. Based upon this investigation, it was determined that a site located in the Western Coal Field of Kentucky, near Madisonville, was the most suitable for implementation of the revegetation concept.

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SECTION I

CONCLUSIONS

1. This study has shown that a demonstration of the reuse of treated active surface mine drainage for revegetation augmentation on regraded spoil banks is feasible at the Vogue Mine and that this site meets the requirements of Section 14 of the Federal Water Pollution Control Act.

2. The chemistry of the regraded spoil banks and of the pit water at the Vogue site is conducive to the demonstration of the engineering economic feasibility of this technique.

3. The effluent from the treatment facility can be applied as irrigation water to insure higher vegetative survival by:

   a. Supplying adequate moisture to assure germination and survival during the sensitive seedling stage.

   b. Providing the required water supply for maximum plant growth.

   c. Providing an abundant water supply to maintain spoil surface temperatures within tolerable limits for plant survival.

   d. Supplying alkaline particles to neutralize entrapped toxic material in the spoil.

4. Observed preliminary flow data and recorded climatological information indicate that during the normal low rainfall periods of the area all of the effluent from the treatment facility can be applied as irrigation water. This will substantially reduce the amount of total dissolved solids entering the receiving streams.

5. The investigation of the Colonial Mine site concluded that this site would not be suitable for a demonstration as outlined in the Federal Grant for the following reasons:

a. The relatively high quality of the pit water and the location of the pit with relation to the receiving stream result in an effluent discharge that is acceptable to the strip mine regulations as enforced by the Commonwealth of Kentucky.

b. The chemist[illegible] of the spoil and evidence of volunteer vegetation at this site indicate that a vegetative cover can be established with minimal effort by the operator.

SECTION II

RECOMMENDATIONS

1. It is recommended that an on-site, semi-portable treatment facility, utilizing pulverized limestone and sized to handle the total pit discharge, be engineered, constructed and operated at the Vogue mine site. This facility would be operated for a period of two years, from July, 1973, through June, 1975.

2. The treating facility should be engineered and constructed using standard "off the shelf" equipment, modified for semi-portability, to be compatible with the transient nature of surface mining technique in western Kentucky.

3. The engineering, installation and operation of a semi-portable high pressure spray irrigation system is recommended to operate in conjunction with the treatment facility for the same period of time. The revegetated demonstration area would consist of approximately 25 acres utilizing the irrigation technique and a control plot of approximately 5 acres with no irrigation and using the standard minimum strip mine regulation requirements for revegetation.

4. Pulverized limestone should be used as the neutralizing agent, since the carry-over of the unreacted limestone is not likely to raise the pH of the spoil above 7.5; also, it would take a longer time for the spoil to reach this level using limestone that it would if hydrated lime were utilized.

5. In order to document the effectiveness of the project, it is recommended that monitoring stations, which record flow, pH and conductivity, be installed at the following points:

    a. Isaacs Creek above and below the demonstration site to record the effect of this demonstration on the receiving stream.

b. The discharge of the treating facility to assure compliance with the strip mine regulations of the Commonwealth.

c. Drainage ditches adjacent to the irrigated and non-irrigated test plots. These would provide data relative to ground water and surface runoff of spoil banks as affected by revegetation.

6. One of the prime objectives of the project is to eliminate or reduce the total dissolved and suspended solids entering the receiving streams. Therefore, it is recommended the operation of the irrigation system would be based upon stressing the system to the point of maximum capability of the spoil material to absorb moisture and the carry-over of suspended and dissolved solids without suffering loadings detrimental to vegetative survival.

7. Western Kentucky has both active and orphaned areas contributing to waterway and aesthetic pollution. Since there is a lack of recorded evidence on demonstrating the use of anhydrous ammonia for the treatment of acid mine water, it is recommended that an investigation be conducted to select a site (active or orphaned) suitable for this purpose and using the effluent for spray irrigation.

   There are several advantages associated with a demonstration of this classification:

   a. Document the engineering economic feasibility of treating acid mine drainage using anhydrous ammonia.

   b. In the reaction of anhydrous ammonia with water containing free sulfuric acid, one of the products is ammonium sulfate, commonly used as a fertilizer. This could have a beneficial effect on plant growth.

   c. Demonstrate the feasibility of off-season revegetation of spoil banks utilizing treated acid mine water to provide an abundant supply of moisture and plant nutrients.

SECTION III

INTRODUCTION

General Discussion

Kentucky coal occurs in two major fields - the Eastern Kentucky Coal Field and the Western Kentucky Coal Field. The former lies within the Appalachian Coal Region, while the latter occupies the southern extremity of the Eastern Interior Coal Basin. These fields are widely separated geographically and the quality of the coals varies considerably. The coal of both fields belongs to the Pennsylvania system.

The Western Kentucky Coal Field encompasses an area of 4,680 square miles in 21 counties. The coals produced rank within the high-volatile bituminous A, B or C classification. At least eight principal seams are mined with the seams averaging between five and seven feet in thickness. Coals in this field are widely used for steam generation purposes.

In 1970, the Western Kentucky Coal Field produced a total of 52.7 million tons of coal with surface mining producing 63 percent of the total. The mining activity in Western Kentucky is summarized in Table 1. Muhlenberg County is the largest coal-producing county in the nation.

With the terrain flat to gently rolling, many of the surface mines operate with the pit floor well below the water table, necessitating pumping in order to remove collected drainage. The discharge from the pits varies from periodic to continuous, depending on the season of the year as well as the particular location of each pit. The drainage is presently discharged untreated onto spoil banks where it eventually reaches a stream, or it is discharged untreated directly to a stream.

The nature of the terrain requires effective surface drainage control techniques, otherwise excessive volumes of runoff would enter the pits and require pumping. The depth of the pits below water table plus the runoff from the immediate spoil banks accounts for the water entering the pits, which must be discharged by pumping if

TABLE 1
SUMMARY OF COAL MINING IN WESTERN KENTUCKY
1965 THROUGH 1970

Year	Permits and Supplements	Strip Mine Operators	Acreage Permitted	Production-Surface	Underground Mines	Production-Underground	Total Production
1965	60	45	4,463	26,537,294	49	13,341,646	39,878,940
1966	56	43	4,442	27,104,309	40	14,878,164	41,982,473
1967	68	46	4,220	29,740,962	45	15,872,844	45,613,806
1968	91	43	3,697	28,325,046	40	17,805,636	46,130,682
1969	106	126	4,852	28,167,862	35	19,834,278	48,002,140
1970	159	73	6,392	33,281,946	34	19,430,489	52,712,435

operations are to be conducted. Thus, primary consideration for alleviation of the pollution problem rests with the use of adequate and practical treatment techniques applicable to the drainage before discharge.

The treatment scheme used for drainage control must lend itself to the transient nature of the stripping operation; the treatment plant must be able to be transported from site to site as the operating pit is moved and the spoil banks are regraded to contour. Since revegetation of the regraded spoil banks is required, and the high evapotranspiration rate in summertime plus the porous nature of the spoil makes vegetative survival difficult, a treatment scheme that allows final use of the drainage water for irrigation of the spoil at least during summer months would have many advantages.

In both cases of discharge of drainage to streams and treated drainage to spoil irrigation, the primary process of choice is neutralization followed by aeration for conversion of the ferrous iron content to ferric iron. This neutralization process is in widespread use and the equipment for controlling the addition of the treatment lime or limestone is proven and readily available.

Project Objective

The objective of the study conducted was to determine the feasibility of utilizing such neutralized acid mine drainage, from active surface mines, to irrigate new vegetative cover on regraded spoil banks to achieve higher vegetative survival and to eliminate pollution of surface water courses at two independent mine sites. An inherent determination in establishing such feasibility was the demonstration of the practicability of combining and arranging available treatment equipment in a semi-portable unit to allow resultant neutralized oxidized discharge from the process to either:

1. be spread directly on regraded, prepared, revegetated spoil bank areas as irrigation water, or

2. be clarified in temporary settling ponds for ultimate discharge to a receiving stream during periods of high rainfall.

Neutralization of the acid mine water will be accomplished by utilizing pulverized limestone, since unreacted limestone has a residual beneficial effect when used in the irrigation water. Commercially available neutralization modules will be used.

A scheme so designed would allow maximum spoil bank irrigation, with an alternate discharge to a receiving stream, depending on the water saturation of the spoil area. The entire process need have a lifetime of only that of the active pit operation, since upon termination of the permit the entire area is regraded and the pit either filled with earth or an impoundment developed. In either case, the exposed coal seam at the highwall is completely excluded from air.

General Description of Project

Pumping from the operating pit of surface mines becomes more frequent during high rainfall periods when the spoil area would be saturated with water and unable to absorb irrigation water; therefore, an alternate method of disposal of the treated effluent is required. Temporary settling ponds will be used for sludge settling during these periods. Since the pond would be used only for the life of the single strip, no sludge handling is required. The sludge that accumulates in the settling lagoon will be covered in the regrading process as the active pit area moves with the mining schedule. The effluent will have an iron level of less than 7 ppm and a dissolved solids content that will be a function of the pH and the solubility product constants of the various chemical constituents present in the water being treated.

The three primary benefits to be derived from the use of the treated mine drainage for irrigation purposes are as follows:

1. Supplying water to the spoil during the summer months would alleviate the lack of adequate moisture, one of the most detrimental conditions affecting survival of new vegetation.
2. Flushing of the upper soil layers removes salts and acids accumulated by oxidation during periods of dryness.
3. The discharge of a highly mineralized water to a receiving stream will be greatly reduced or eliminated during periods of low flow by spraying the treated water on spoils.

During those periods when irrigation may be employed almost continuously in July, August, September and October, records indicate an average monthly 3.5 inches of rainfall. This amount deducted from an average of 0.25 inches per day for evapo-transpiration gives a maximum of 4 inches of water per month for irrigation. On this basis, a 500 gpm treatment plant, operating eight hours per day, as projected at the Vogue site, five days per week, would be able to irrigate as originally conceived approximately 45 acres of spoil. This area is reasonable in terms of the size of the permit areas and the various pumping rates encountered.

Use of irrigation would require taking the effluent from the neutralization unit and pumping the water and suspended solids through aluminum irrigation piping to spray nozzle headers on the graded spoil area. In addition to the irrigated area, a companion control area of approximately 5 acres non-irrigated would be established.

The neutralization plant would employ standard "off the shelf" equipment. Such equipment is suitable for use with either hydrated lime or pulverized limestone. While limestone has been shown to be less efficient than hydrated lime (50-75%), the unreacted limestone has a residual benefit on the spoil. A trial using limestone at the Vogue (No. 1) site is projected. Limestone consumption is estimated at 1000 pounds per hour. The Colonial site was originally planned for the use of hydrated lime. As a result of the relatively high quality of the discharge water as revealed by this Feasibility Study, it was determined that further treatment would not be required.

The entire set of equipment would be constructed in modular fashion for easy movement from site to site. A self-contained diesel electric power plant would be one of the modular units and would supply all power for the pumps and control equipment.

Operation of the irrigation project would take at least two growing seasons to reach any definitive estimate of benefits of irrigation, and thus the project should be operated for two full years.

Appropriate statistical analyses will be made of the test areas to verify the differences between the irrigated and non-irrigated areas, as well as documenting the overall success of the operation.

Effectiveness of Project

In fulfillment of requirements of the project, treatment facilities would be designed to treat the total pit effluent to a level acceptable for discharge to any receiving stream, in accordance with state Water Quality Standards. (Refer to Appendices for appropriate Kentucky Revised Statutes and SMR-Rg-11.) This is important to the performance of the project because, during periods of high rainfall when the spoil area would be saturated and unable to absorb irrigation water, the treated effluent would be diverted to a temporary settling pond for final clarification prior to discharge to the receiving stream. Treatment of the acid mine water is essential to the establishment of good vegetative cover, since plant life cannot survive on the untreated water and abundant growth is necessary for restoration of disturbed land. It is also required to effect substantial improvement in the quality of receiving streams which may be used for other purposes by industry and the general populace.

Effective operation of the demonstration project would completely eliminate the discharge of untreated acid mine drainage from the project site to the local receiving stream, since all pit drainage would be treated with the application of limestone for neutralization of the acidic content. Significant reduction of spoil bank erosion would also be evident since vegetative cover would flourish under close control of the growing conditions for the control area. Soil acidic conditions would be neutralized by the treatment imposed and sufficient water, conveying essential nutrients, would be supplied to the spoil bank by irrigation. Contaminated surface runoff would be eliminated since all acid mine drainage water at the site would be subjected to treatment and/or clarification before it is discharged to the receiving waterways. Under the performance of the project, everything aforementioned should be done to bring efforts to reclaim the land and to improve the water quality in compliance with existing standards. Efforts successfully carried out would do much to establish improved methods for compliance with laws, result in more substantial vegetative renewal on poor land areas, effect better control of potential public hazards, help to restore public waters to greater potential uses by the general public and establish more rapid vegetative renewal. Implementation of the demonstration concept throughout the Commonwealth would result in a considerable advance in reestablishing all disturbed land to more natural conditions.

SECTION IV

JURISDICTIONAL FRAMEWORK

Cognizant Authority

This study has been conducted under the auspices of the Environmental Protection Agency. The Agency is subject to the provisions of the Water Quality Improvement Act of 1970, PL 91-224. The Act includes a subsection titled "Area Acid and Other Mine Water Pollution Control Demonstrations" which became Section 14 of the Federal Water Pollution Control Act, as amended. This section provides for the demonstration of techniques for mine drainage pollution control and directs that the Environmental Protection Agency shall require such feasibility studies as required in selecting watersheds for the purpose of the demonstration projects. Such feasibility studies are to aid the Environmental Protection Agency in selecting not only the mine drainage pollution control method(s), but also the watershed or drainage area for such application. The Act requires that the Environmental Protection Agency give preference to areas which will have the greatest public value and uses.

The Environmental Protection Agency, Office of Research and Monitoring, issued a grant for the mine drainage demonstration project, described herein, to the Commonwealth of Kentucky, Department of Natural Resources, Division of Reclamation. Administration of the study has been the responsibility of the Commonwealth of Kentucky's Department of Natural Resources.

The Department of Natural Resources is a statutory unit of the Kentucky government headed by a Commissioner. The legislative basis for the department may be found in Kentucky Revised Statutes (KRS) 146.010. The department has the authority to exercise all state administrative functions relating to the conservation and protection of natural resources (except wildlife), flood control, municipal and industrial water usage, and strip mining and reclamation. These functions are carried out by the following five divisions in the department:

Division of Beautification
Division of Forestry
Division of Reclamation
Division of Soil and Water
Division of Water

Chapter 350 of the Kentucky Revised Statutes is one of the most modern and effective strip mining and reclamation laws in the United States. Under KRS 350.024 a Reclamation Commission was created in the Department of Natural Resources. (See Appendices for KRS 350.024 Reclamation Commission; Membership; Meetings; Compensation.)

The Kentucky General Assembly, under KRS 350, have vested in the Division of Reclamation and Reclamation Commission the authority to regulate and control strip mining of coal to minimize or prevent its injurious effects on the people and resources of the Commonwealth. The Division of Reclamation under the supervision of the Commissioner of Natural Resources has the following authority and powers (see Appendices for KRS 350.050 Powers of Division) relative to this project:

1. To encourage and conduct investigations, research, experiments and demonstrations, and to collect and disseminate information relating to strip mining and reclamation of lands and waters affected by strip mining;

2. To adopt, without hearing, rules and regulations with respect to the filing of reports, the issuance of permits and other matters of procedure and administration;

3. To examine and pass upon all plans and specifications submitted by the operator for the method of operation, backfilling, grading and for the reclamation of the area of land affected by his operation;

No operator in the Commonwealth of Kentucky is allowed to engage in strip mining without having first obtained from the Division of Reclamation a permit designating the area of land affected by the operation. Permit requirements are described under KRS 350.060. (See Appendices for KRS 350.060 Permit Required; Contents of Application; Map; Fee; Bond.)

An operator is required to have a drainage plan. This plan must indicate the directional flow of water, constructed drainways, natural waterways used for drainage, and the streams or tributaries receiving the discharge. In addition to the method of operation, grading, backfilling and reclamation, the operator is required to perform the following:

1. Cover the face of the coal with compacted nonacid bearing and nontoxic materials to a distance of at least four feet above the seam being strip mined or by a permanent water impoundment;

2. Bury under adequate fill all toxic materials, roof coal, pyritic coal or shale determined by the division to be acid producing, toxic, or creating a fire hazard;

3. Seal off, as directed by regulations, any breakthrough of acid water creating a hazard;

4. Impound, drain or treat all runoff water so as to reduce soil erosion, damage to agricultural lands and pollution of streams and other waters;

5. Remove or bury all metal, lumber, and other refuse resulting from the operation;

6. Revegetate with suitable seed or plant mixtures after approved regrading and soil preparation.

The project, as presented, is a demonstration of methods of improved reclamation of strip mine areas. It is in keeping with the foregoing Kentucky Revised Statutes on reclamation and shall serve to expand upon the intent of several points of the law. The project will be conducted by one of the regulatory agencies responsible for the enforcement of all applicable laws and thereby has all administrative authority to efficiently carry out the project in compliance with the existing laws.

Since the Division of Reclamation is the grantee for the performance of the project, it will be conducted under authority established in the law (KRS 350) for the Division to encourage and conduct demonstrations related to the reclamation of lands and waters affected by strip mining.

Upon completion of the project, the Division is also charged with the dissemination of information collected during progress of the report.

Existing and Proposed Standards

The site of the demonstration project is within the jurisdiction of the Commonwealth of Kentucky. The streams involved are considered public streams of the Commonwealth and are therefore subject to the Federally approved Kentucky Water Quality Standards for Interstate Waters.

The water quality of the public streams, within the confines of the Commonwealth of Kentucky, is maintained through the authority vested in the Water Pollution Control Commission of the Commonwealth, under Kentucky Revised Statute (KRS) 224.040. The applicable standards by which said authority is administered are covered by regulation WP-4-1, "Water Quality Standards for Waters of the Commonwealth of Kentucky", adopted July 23, 1971, which relates to KRS 224.010 to 224.210 and 224.990. (See Appendices for Regulation WP-4-1.)

In accordance with the performance of the demonstration project, a treatment plant would be installed at the selected site to neutralize acid mine water before it is pumped to spoil banks to augment revegetative survival; and monitoring stations would be placed at selected sites in the effluent streams to monitor flow, pH and conductivity.

The project is in keeping with laws regulating and controlling strip mining of coal within the Commonwealth, since operators must now have a drainage plan for the sites of their operations. Also, under current law, a major requirement exists for the reclamation of all worked-out sites, and includes provisions for treatment of runoff water and the revegetation of the regraded areas. The project serves to carry out such requirements, demonstrating new methods of performing same and improving upon the results expected.

Since the project would be conducted under the direction of the Division of Reclamation, all aspects of applicable regulations would be strictly observed, since it is the body charged with monitoring and enforcement. The Division would maintain supervision of all Contractors and personnel selected to carry out the various tasks associated with the successful implementation of the project.

The project will meet all water quality criteria set by the Commonwealth (see Appendices for WP-4-1 and KRS 350.090).

Site Acquisition

The site chosen for the demonstration project is located within the Commonwealth of Kentucky. The authority to acquire, restore and reclaim land, as required for the project, is vested in the Commonwealth of Kentucky in accordance with Kentucky Revised Statutes relating to strip mining and reclamation, KRS 350.152, 350.154 and 350.156, which are included in the Appendices of this Report.

Land selected for the performance of the project, Vogue Mine site, is held in private ownership. Peabody Coal Company, operator of the mine, is the owner of all surface rights and has leased the mineral rights for the life of the mine. The mineral rights have been leased from Terteling Brothers, Inc., 611 First Security Bank Building, Boise, Idaho.

In the normal progress of the reclamation project presented, it is not anticipated that transfer of the property will be required; especially since a formal working agreement for conducting the project has been made between the parties concerned. Acquisition of the property by purchase or under the power of eminent domain would only become necessary if severe health or safety hazards were encountered under the present ownership arrangements, or the owners defaulted on their responsibility to restore all strip mined land.

Authority for Funding

Federal funding for this project was provided by way of a grant to the Commonwealth by the Environmental Protection Agency under authority of Section 14 of the Federal Water Pollution Control Act, as amended. The grant offer was made to the Commonwealth of Kentucky's Department of Natural Resources, Division of Reclamation. The Division of Reclamation is permitted to accept Federal and other funds in accordance with Kentucky Revised Statutes (KRS) 350.150 and 350.163 which are included in the Appendices of this Report.

All sums received through the payment of fees, forfeiture of bonds and federal grants are placed in the State Treasury. The Division of Reclamation receives a general fund appropriation on a bi-annual basis as approved by the Kentucky General Assembly. Funds are expended for the administration and enforcement of Kentucky Revised Statute 350 and for the reclamation of improperly reclaimed strip mined lands. Expenditure of funds is administered by the Director of the Division of Reclamation.

Water and Mineral Rights

Property ownership and the associated holding of water and/or mineral rights for areas designated as sites for the demonstration project presented herein are not of major concern. A working agreement, by mutual affirmation, is in effect between the Commonwealth of Kentucky (Grantee) and the operator of the active surface mine selected as a site for the demonstration.

No transfer of property and/or rights is anticipated with the performance of the demonstration project. The working agreement entered into with each coal operator provides that the grantee will conduct the project so as not to interfere with the mining operations; and likewise the operator will not interfere with the performance of the project. All streams running through the properties are considered public streams of the Commonwealth and are subject to all applicable Federal and Commonwealth Water Quality Standards. The operators of the mines are subject to all existing standards concerning water quality and regulations for reclamation which apply to the workings and adjacent property covered by the boundaries stipulated in the property title, lease, etc. However, for the duration of the demonstration described herein, the grantee shall assume such responsibility only for the demonstration site. Upon completion of the project, such responsibilities shall once again revert to the mine operator and/or property owner.

Peabody Coal Company owns the surface and is leasing the mineral rights at the recommended site.

Water used in the irrigation phase of the project would be recycled to the stream, as ground water, unless actively used to support vegetation or lost by evaporation. Therefore, no water rights are required for performance of the project since the water courses would be maintained except for irrigation pumping requirements and neutralization treatment of the acidic stream, both of which will be beneficial to the receiving stream. This is in keeping with Commonwealth of Kentucky water rights law since surface water flowing in a stream or definite channel is not subject to ownership, in accordance with 1954 legislation (KRS 262.670 to 262.690), which states in part:

> The owner of land contiguous to public water shall have the right to such reasonable use of this water for other than domestic purposes as will not deny the use of such water to other owners for domestic purposes, or impair existing uses of other owners heretofore established, or unreasonably interfere with a beneficial use by other owners. (KRS 262.690-2)

Prevention of Future Pollution

The Division of Reclamation and Reclamation Commission of the Department of Resources of the Commonwealth of Kentucky have the authority to regulate and control the quality of drainage water emanating from strip mining operations in the Commonwealth. The existing standards and regulations which have been established to protect the people and resources of the Commonwealth from the injurious effects of untreated and uncontrolled strip mine operations are vested in these agencies under Kentucky Revised Standards (KRS) 350. An applicable section of the standards, Strip Mine Regulation - Rg. 11, RE: Water Quality, adopted October 1, 1971, is included in the Appendices of this Report.

In addition to this regulation, the Kentucky Water Pollution Control Commission is charged with safeguarding the uncontaminated waters of the Commonwealth, preventing the creation of new pollution in the waters of the Commonwealth, and abating existing pollution. For this purpose the Kentucky Legislature created in the Department of Health the Water Pollution Control Commission. (See Appendices for 224.030 Water Pollution Control Commission; creation; membership; compensation; meetings, officers and employes.)

The authority, powers and duties of the Water Pollution Control Commission are identified in KRS 224.040 Powers and duties of commission (see Appendices).

The laws and regulations of the Commonwealth, in conjunction with the authority to assure compliance of these laws and regulations, as described above, assure the Federal Government that the area will not be affected adversely by the influx of acid or other mine water pollution from nearby sources.

SECTION V

INVENTORY AND FORECAST

Physical Conditions

Five sites of active mining, in the vicinity of the Madisonville field office of the Department of Reclamation, were considered as possible sites for conducting this mine drainage demonstration project. The sites considered were as follows:

Vogue Mine, Peabody Coal Company, Permit 29-69, Supplement No. 6 (Site No. 1)

Volunteer Mine, Cimarron Coal Company, Permit 1169-70 and 1169-69 (Site No. 2)

Colonial Mine, Pittsburg and Midway Coal Mining Company, Supplement No. 1 (Site No. 3)

Colonial Mine, Pittsburg and Midway Coal Mining Company, Permit No. 27-70 (Site No. 4)

Walter Wright Mine, Permit No. 453-70 (Site No. 5)

Two sites were selected for development of the project. The sites lie in Muhlenberg and Hopkins Counties in the Western Coal Field of Kentucky near Madisonville. The primary decisive factor in making the selection was the fact that preliminary analyses of the streams at the five sites considered revealed that only two were significantly discharging highly acid mine water. These analyses are reported in Table 2. The sites selected were Site No. 1, (Vogue Mine, Peabody Coal Company, Permit 29-69, Supplement No. 6) and Site No. 4 (Colonial Mine, Pittsburg & Midway Coal Mining Company, Permit 27-70).

The physical conditions at each selected site are as follows:

Vogue Mine, Peabody Coal Company, Permit 29-69, Supplement No. 6 (Site No. 1)

The Vogue Mine is an active operation of the Peabody Coal Company. The mine is an area type, open pit, surface

TABLE 2
MINE DRAINAGE QUALITY
PRELIMINARY MINE SITES

Sampled	Site No.	Location	M.O. Alk.	Free Acid-ity	Total Acid-ity	Spec. Cond. mmhos	pH	Ca	Mg	SO_4	Fe	Al
4/70	1	Vogue Mine, Upper Pit	0	-	2054	4000	3.6	800	384	3958	400	200
5/71	2	Volunteer, East End	202	0	14	2300	6.8	335	250	1960	1.1	0.54
5/71	3	Colonial, Suppl. 1 East End	86	0	8	2300	6.3	545	290	2260	0.7	<0.05
5/71	4	Colonial, South End	0	176	300	3700	2.3	605	418	4230	513	1.6
5/71	4	Colonial, North End	-	-	-	-	-	755	399	4130	508	0.65
5/71	5	Walter Wright, East End	148	0	38	2250	6.1	490	200	1965	1.1	0.06

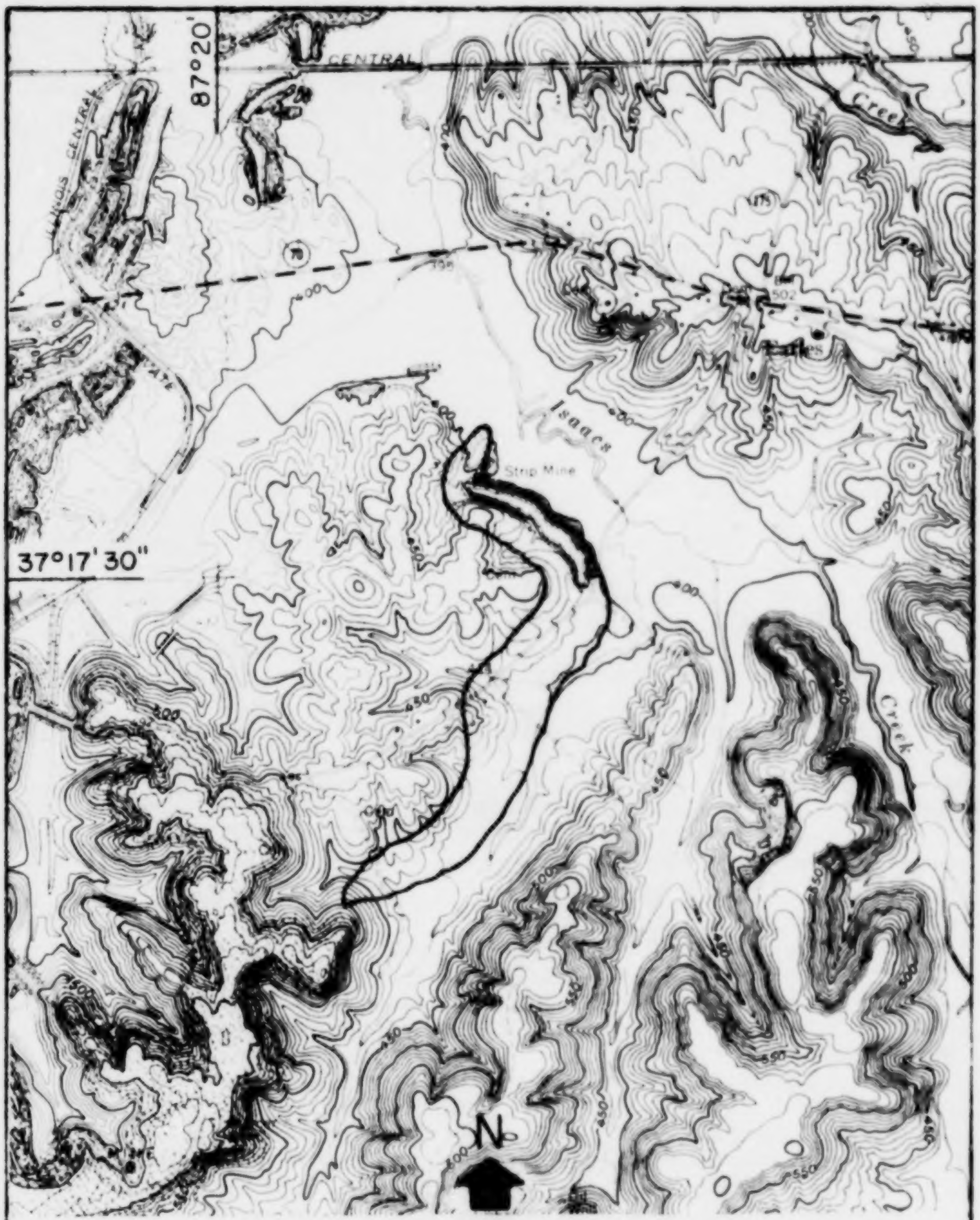
Test results reported in mg/l unless otherwise noted.

mine and is located in Muhlenberg County, Kentucky, approximately 11 miles southeast of Madisonville, Kentucky. It appears on the USGS Millport, Kentucky, quadrangle map at 37° 17' 48" latitude and 87° 19' 18" longitude. The permit area is approximately 100 acres and is shown in Figure 1. Mining is in the No. 9 seam of coal and the pit extends the entire length of the permit area. Although there is no active mining at this site at the present time, the stripping operation will be resumed in the northern portion of the pit in the spring of 1974. During active mining operations, water is pumped from the pit as required to accommodate mining activities. The effluent is pumped into drainways that eventually drain into Isaacs Creek, which drains into the Pond River, which in turn flows into the Green River and then into the Ohio.

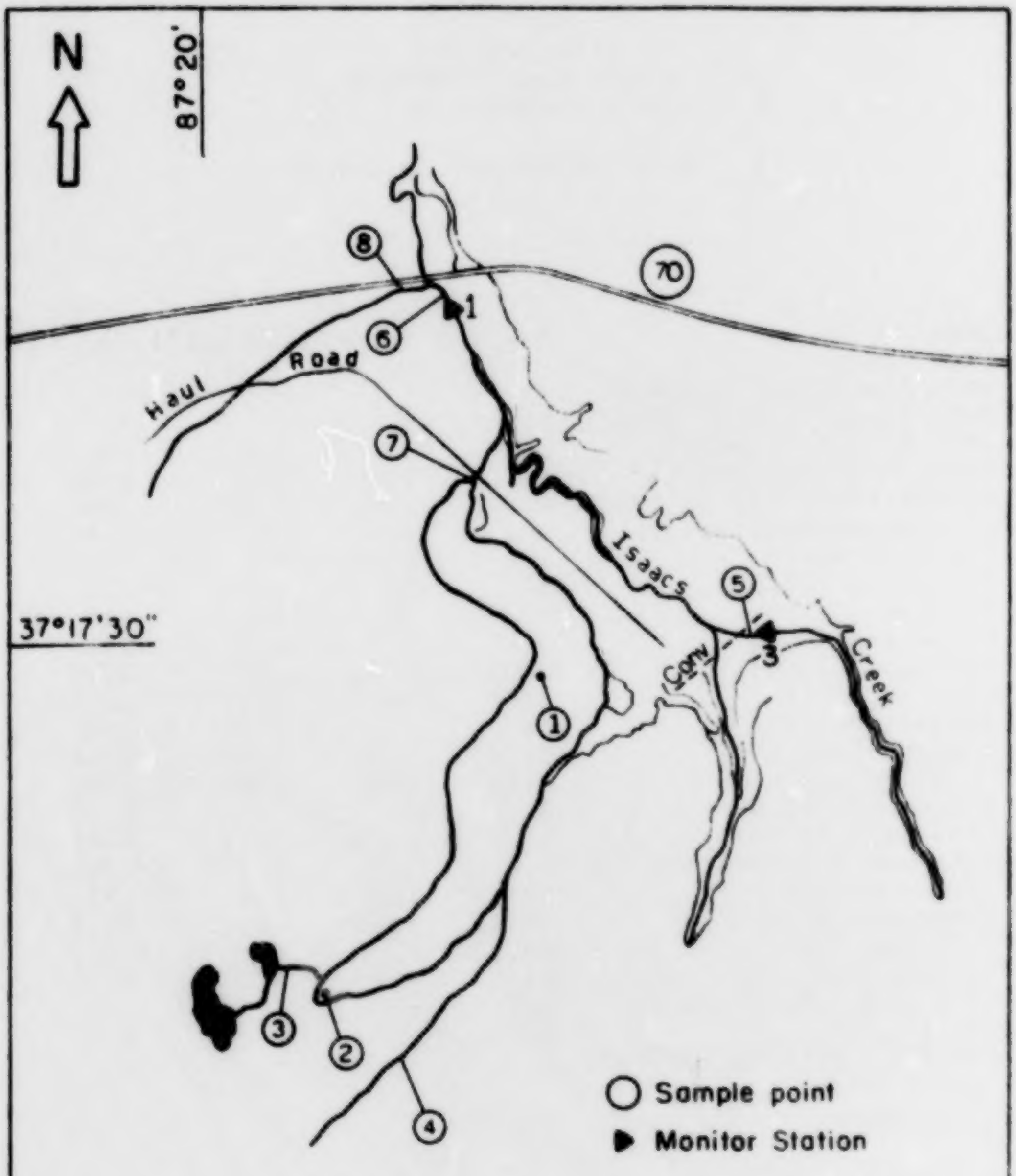
During periods of relatively dry weather, approximately 80% of the total drainage from the Vogue pit originates as drainage from orphaned areas near the southern portion of the strip pit. The quality of the drainage from this area is very poor and shows heavy acid and iron contamination. Samples were collected of the influent and effluent drainage to the pit and of Isaacs Creek, both above and below the drainage from the Vogue strip pit. The geographic locations of these sample points are illustrated in Figure 2. The results of these analyses are tabulated in Tables 3 through 10. These samples were collected periodically over a four month period and represent periods of both high and low water flows.

Colonial Mine, Pittsburg & Midway Coal Mining Company, Permit 27-70 (Site No. 4)

The Colonial Mine is an active operation of the Pittsburg & Midway Coal Mining Company. This operation is also an area type, open pit, surface mine and is located in Hopkins County, Kentucky, approximately seven miles west of Madisonville, Kentucky. It appears on the USGS Madisonville West, Kentucky, quadrangle map at 37° 20' 55" latitude and 87° 35' 49" longitude. The permit area is 120 acres and is shown in Figure 3. Mining is in the No. 14 seam of coal and the pit has been developed almost the entire length of the permit area. Future surface mining activities will be concentrated toward the southern portion of the permit area, since present plans call for the development of a deep mine near the northeastern end of the pit.


87°20'
CENTRAL
ILLINOIS CENTRAL
Creek
37°17'30"
Isaacs
Strip Mine
Creek
N
1000 0 1000 2000 3000
SCALE IN FEET

LOCATION PLAN, VOGUE MINE - FIGURE 1


N
87°20'
37°17'30"
70
Haul Road
Isaacs Creek
Cany
1
2
3
4
5
6
7
8
1
3
○ Sample point
▶ Monitor Station

VOGUE MINE SITE

MONITOR STATION AND SAMPLE POINT LOCATIONS

FIGURE 2

TABLE 3
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 1 ①

VOGUE STRIP PIT (MID-PIT)

Date	8/17/71	9/10/71	10/13/71	11/3/71
Flow (gpm)	-	-	-	-
Pht. Alkalinity (CaCO$_3$)	-	-	-	-
M.O. Alkalinity (CaCO$_3$)	-	-	-	-
Free Acidity (CaCO$_3$)	400	375	302	630
Total Acidity (CaCO$_3$)	1160	1120	1310	1382
Conductivity (25°C) mmhos.	4160	4500	4100	3540
pH (electrometrically)	3.0	2.8	3.0	2.8
Color (APHA)	130	60-70	-	-
Turbidity (JTU)	54	14	-	-
Calcium (Ca)	-	365	400	427
Magnesium (Mg)	-	210	235	246
Hardness (CaCO$_3$)	2400	1774	1966	2077
Sulfate (SO$_4$)	3600	2920	3050	3260
Total Iron (Fe)	94	114	170	144
Ferrous Iron (Fe)	11.9	5.5	7.52	3.54
Total Solids	4458	4682	5250	5281
Suspended Solids	31	24	17	5
Dissolved Solids	4427	4658	5233	5276
Settleable Solids (ml/l)	0.6	0.2	0.2	<0.1
Aluminum (Al)	92	130	132	123
Manganese (Mn)	40.2	41.0	47.0	48.1
Chloride (Cl)	<0.17	-	-	-
Sodium (Na)	84	-	-	-
Potassium (K)	6.3	-	-	-
Copper (Cu)	0.39	-	-	-
Hot Pht. Acidity (CaCO$_3$)	-	-	-	-

Test results reported in ppm unless otherwise noted.

① Refer to Figure 2 for location of sample point.

TABLE 4
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 2 ①

SOUTH END OF VOGUE STRIP MINE

Date	8/17/71
Flow (gpm)	5
Pht. Alkalinity ($CaCO_3$)	-
M.O. Alkalinity ($CaCO_3$)	-
Free Acidity ($CaCO_3$)	620
Total Acidity ($CaCO_3$)	1040
Conductivity (25°C) mmhos.	5700
pH (electrometrically)	2.9
Color (APHA)	156
Turbidity (JTU)	230
Calcium (Ca)	-
Magnesium (Mg)	-
Hardness ($CaCO_3$)	3050
Sulfate (SO_4)	4650
Total Iron (Fe)	256
Ferrous Iron (Fe)	148
Total Solids	6484
Suspended Solids	112
Dissolved Solids	6372
Settleable Solids (ml/l)	4
Aluminum (Al)	20
Manganese (Mn)	25.6
Chloride (Cl)	<0.17
Sodium (Na)	250
Potassium (K)	19.0
Copper (Cu)	0.13
Hot Pht. Acidity ($CaCO_3$)	-

Test results reported in ppm unless otherwise noted.

① Refer to Figure 2 for location of sample point.

TABLE 5
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 3 ①

POND WEST OF VOGUE STRIP PIT

Date	8/17/71	9/7/71	10/13/71
Flow (gpm)	-	-	185
Pht. Alkalinity ($CaCO_3$)	-	-	-
M.O. Alkalinity ($CaCO_3$)	-	-	-
Free Acidity ($CaCO_3$)	970	950	458
Total Acidity ($CaCO_3$)	1950	2185	2190
Conductivity (25°C) mmhos.	5420	4320	4870
pH (electrometrically)	2.8	2.8	2.8
Color (APHA)	230	>70	-
Turbidity (JTU)	68	51	-
Calcium (Ca)	-	283	455
Magnesium (Mg)	-	314	300
Hardness ($CaCO_3$)	3300	1995	2371
Sulfate (SO_4)	5380	4263	4560
Total Iron (Fe)	334	100	415
Ferrous Iron (Fe)	35.6	2.97	16.1
Total Solids	6953	6754	7473
Suspended Solids	27	22	37
Dissolved Solids	6926	6732	7436
Settleable Solids (ml/l)	0.5	0.3	0.2
Aluminum (Al)	174	85	212
Manganese (Mn)	49.2	30.0	75.0
Chloride (Cl)	<0.17	-	-
Sodium (Na)	124	-	-
Potassium (K)	4.6	-	-
Copper (Cu)	0.45	-	-
Hot Pht. Acidity ($CaCO_3$)	-	-	-

Test results reported in ppm unless otherwise noted.

① Refer to Figure 2 for location of sample point.

TABLE 5 (Cont'd)
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 3 ①

POND WEST OF VOGUE STRIP PIT

Date	11/3/71	1/19/72
Flow (gpm)	15	-
Pht. Alkalinity ($CaCO_3$)	-	-
M.O. Alkalinity ($CaCO_3$)	-	-
Free Acidity ($CaCO_3$)	1400	502
Total Acidity ($CaCO_3$)	2550	1214
Conductivity (25°C) mmhos.	5080	4140
pH (electrometrically)	2.6	2.7
Color (APHA)	-	>70
Turbidity (JTU)	-	60
Calcium (Ca)	498	411
Magnesium (Mg)	325	451
Hardness ($CaCO_3$)	2578	2877
Sulfate (SO_4)	4610	3450
Total Iron (Fe)	306	196
Ferrous Iron (Fe)	7.93	68.3
Total Solids	7653	5329
Suspended Solids	17	38
Dissolved Solids	7636	5291
Settleable Solids (ml/l)	0.1	0.3
Aluminum (Al)	207	118
Manganese (Mn)	76.3	48.4
Chloride (Cl)	-	-
Sodium (Na)	-	-
Potassium (K)	-	-
Copper (Cu)	-	-
Hot Pht. Acidity ($CaCO_3$)	-	-

Test results reported in ppm unless otherwise noted.

① Refer to Figure 2 for location of sample point.

TABLE 6
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 4 ①

HEADWATERS OF UNNAMED TRIBUTARY TO ISAACS CREEK

Date	8/17/71
Flow (gpm)	-
Pht. Alkalinity ($CaCO_3$)	-
M.O. Alkalinity ($CaCO_3$)	-
Free Acidity ($CaCO_3$)	103
Total Acidity ($CaCO_3$)	250
Conductivity (25°C) mmhos.	2760
pH (electrometrically)	3.2
Color (APHA)	8
Turbidity (JTU)	4
Calcium (Ca)	-
Magnesium (Mg)	-
Hardness ($CaCO_3$)	1600
Sulfate (SO_4)	1920
Total Iron (Fe)	8.0
Ferrous Iron (Fe)	6.21
Total Solids	2510
Suspended Solids	3
Dissolved Solids	2507
Settleable Solids (ml/l)	0.1
Aluminum (Al)	21
Manganese (Mn)	29.2
Chloride (Cl)	3.58
Sodium (Na)	36
Potassium (K)	7.8
Copper (Cu)	0.17
Hot Pht. Acidity ($CaCO_3$)	-

Test results reported in ppm unless otherwise noted.

① Refer to Figure 2 for location of sample point.

TABLE 7
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 5 ①

ISAACS CREEK NEAR CONVEYOR BELT

Date	8/17/71	9/7/71	10/13/71
Flow (gpm)	900	900	1050
Pht. Alkalinity ($CaCO_3$)	-	-	-
M.O. Alkalinity ($CaCO_3$)	-	-	-
Free Acidity ($CaCO_3$)	720	330	426
Total Acidity ($CaCO_3$)	1660	980	1780
Conductivity (25°C) mmhos.	4820	2640	4350
pH (electrometrically)	2.9	2.8	2.9
Color (APHA)	152	20	-
Turbidity (JTU)	32	56	-
Calcium (Ca)	-	234	382
Magnesium (Mg)	-	163	275
Hardness ($CaCO_3$)	2900	1253	2086
Sulfate (SO_4)	4510	2034	3620
Total Iron (Fe)	164	6.5	245
Ferrous Iron (Fe)	22.0	1.88	11.3
Total Solids	5908	3334	6207
Suspended Solids	14	48	23
Dissolved Solids	5894	3286	6184
Settleable Solids (ml/l)	0.2	0.9	0.4
Aluminum (Al)	150	60	204
Manganese (Mn)	65.6	38.0	85.0
Chloride (Cl)	0.17	-	-
Sodium (Na)	46	-	-
Potassium (K)	5.0	-	-
Copper (Cu)	0.35	-	-
Hot Pht. Acidity ($CaCO_3$)	-	-	-

Test results reported in ppm unless otherwise noted.

① Refer to Figure 2 for location of sample point.

TABLE 7 (Cont'd)
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 5 ①

ISAACS CREEK NEAR CONVEYOR BELT

Date	11/3/71	1/19/72
Flow (gpm)	900	-
Pht. Alkalinity ($CaCO_3$)	-	-
M.O. Alkalinity ($CaCO_3$)	-	-
Free Acidity ($CaCO_3$)	806	460
Total Acidity ($CaCO_3$)	1816	824
Conductivity (25°C) mmhos.	4300	2720
pH (electrometrically)	2.8	2.7
Color (APHA)	-	40-50
Turbidity (JTU)	-	64
Calcium (Ca)	469	243
Magnesium (Mg)	258	219
Hardness ($CaCO_3$)	2231	1506
Sulfate (SO_4)	3530	2009
Total Iron (Fe)	160	100
Ferrous Iron (Fe)	6.23	25.5
Total Solids	5943	3225
Suspended Solids	10	80
Dissolved Solids	5933	3145
Settleable Solids (ml/l)	<0.1	1.4
Aluminum (Al)	173	91.9
Manganese (Mn)	79.8	46.7
Chloride (Cl)	-	-
Sodium (Na)	-	-
Potassium (K)	-	-
Copper (Cu)	-	-
Hot Pht. Acidity ($CaCO_3$)	-	-

Test results reported in ppm unless otherwise noted.

① Refer to Figure 2 for location of sample point.

TABLE 8
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 6 ①

ISAACS CREEK ABOVE RT. 70

Date	8/17/71	9/8/71	10/13/71
Flow (gpm)	-	9425	945
Pht. Alkalinity ($CaCO_3$)	-	-	-
M.O. Alkalinity ($CaCO_3$)	-	-	-
Free Acidity ($CaCO_3$)	535	220	183
Total Acidity ($CaCO_3$)	1240	632	1010
Conductivity (25°C) mmhos.	4250	2350	3900
pH (electrometrically)	2.9	2.9	3.0
Color (APHA)	260	20	-
Turbidity (JTU)	180	125	-
Calcium (Ca)	400	223	387
Magnesium (Mg)	139	133	250
Hardness ($CaCO_3$)	1580	1103	1995
Sulfate (SO_4)	3560	1672	2850
Total Iron (Fe)	106	23	125
Ferrous Iron (Fe)	14.1	8.51	8.32
Total Solids	5226	2662	5092
Suspended Solids	71	51	111
Dissolved Solids	5155	2611	4981
Settleable Solids (ml/l)	5.0	1.0	7.5
Aluminum (Al)	124	1.5	128
Manganese (Mn)	57.2	9.6	60.0
Chloride (Cl)	3.51	-	-
Sodium (Na)	56	-	-
Potassium (K)	5.8	-	-
Copper (Cu)	0.32	-	-
Hot Pht. Acidity ($CaCO_3$)	-	-	-

Test results reported in ppm unless otherwise noted.

① Refer to Figure 2 for location of sample point.

TABLE 8 (Cont'd)
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 6 ①

ISAACS CREEK ABOVE RT. 70

Date	11/3/71	1/19/72
Flow (gpm)	800	-
Pht. Alkalinity ($CaCO_3$)	-	-
M.O. Alkalinity ($CaCO_3$)	-	-
Free Acidity ($CaCO_3$)	469	220
Total Acidity ($CaCO_3$)	1290	657
Conductivity (25°C) mmhos.	3970	2730
pH (electrometrically)	2.9	2.9
Color (APHA)	-	30-40
Turbidity (JTU)	-	150
Calcium (Ca)	406	217
Magnesium (Mg)	262	145
Hardness ($CaCO_3$)	2089	1138
Sulfate (SO_4)	3070	1896
Total Iron (Fe)	96	78
Ferrous Iron (Fe)	5.2	21.0
Total Solids	4948	3048
Suspended Solids	79	89
Dissolved Solids	4869	2959
Settleable Solids (ml/l)	6.5	2.5
Aluminum (Al)	131	79
Manganese (Mn)	69.2	41.9
Chloride (Cl)	-	-
Sodium (Na)	-	-
Potassium (K)	-	-
Copper (Cu)	-	-
Hot Pht. Acidity ($CaCO_3$)	-	-

Test results reported in ppm unless otherwise noted.

① Refer to Figure 2 for location of sample point.

TABLE 9
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 7 ①

DISCHARGE FROM NORTH END OF VOGUE STRIP PIT

Date	9/10/71	10/13/71	11/3/71
Flow (gpm)	600	175	140
Pht. Alkalinity ($CaCO_3$)	0	-	-
M.O. Alkalinity ($CaCO_3$)	0	-	-
Free Acidity (CaCO3)	440	415	673
Total Acidity ($CaCO_3$)	810	1280	1438
Conductivity (25°C) mmhos.	3760	4070	4110
pH (electrometrically)	2.9	2.8	2.8
Color (APHA)	60	-	-
Turbidity (JTU)	1.4	-	-
Calcium (Ca)	330	394	429
Magnesium (Mg)	195	235	256
Hardness ($CaCO_3$)	1625	1951	2123
Sulfate (SO_4)	3081	3020	3290
Total Iron (Fe)	98	165	130
Ferrous Iron (Fe)	4.4	8.32	2.97
Total Solids	4918	5157	4616
Suspended Solids	29	53	1
Dissolved Solids	4889	5104	4615
Settleable Solids (ml/l)	0.2	1.6	<0.1
Aluminum (Al)	130	120	130
Manganese (Mn)	40	50	48.5
Chloride (Cl)	-	-	-
Sodium (Na)	-	-	-
Potassium (K)	-	-	-
Copper (Cu)	-	-	-
Hot Pht. Acidity ($CaCO_3$)	-	-	-

Test results reported in ppm unless otherwise noted.

① Refer to Figure 2 for location of sample point.

TABLE 9 (Cont'd)
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 7 ①

DISCHARGE FROM NORTH END OF VOGUE STRIP PIT

Date	11/9/71	11/30/71	1/19/72
Flow (gpm)	-	-	-
Pht. Alkalinity ($CaCO_3$)	-	-	-
M.O. Alkalinity ($CaCO_3$)	-	-	-
Free Acidity ($CaCO_3$)	602	680	201
Total Acidity ($CaCO_3$)	1397	1230	555
Conductivity (25°C) mmhos.	4050	3720	2700
pH (electrometrically)	2.8	2.7	2.9
Color (APHA)	-	-	30-40
Turbidity (JTU)	29.0	6.4	12
Calcium (Ca)	390	390	262
Magnesium (Mg)	234	230	160
Hardness ($CaCO_3$)	1934	1918	1311
Sulfate (SO_4)	3180	2992	1723
Total Iron (Fe)	108	110	102
Ferrous Iron (Fe)	2.9	3.07	7.03
Total Solids	5163	4885	2710
Suspended Solids	2	25	18
Dissolved Solids	5161	4860	2692
Settleable Solids (ml/l)	<0.1	0.5	<0.1
Aluminum (Al)	124	10	69.1
Manganese (Mn)	51.7	48.0	33.4
Chloride (Cl)	-	-	-
Sodium (Na)	-	-	-
Potassium (K)	-	-	-
Copper (Cu)	-	-	-
Hot Pht. Acidity ($CaCO_3$)	250	1216	-

Test results reported in ppm unless otherwise noted.

① Refer to Figure 2 for location of sample point.

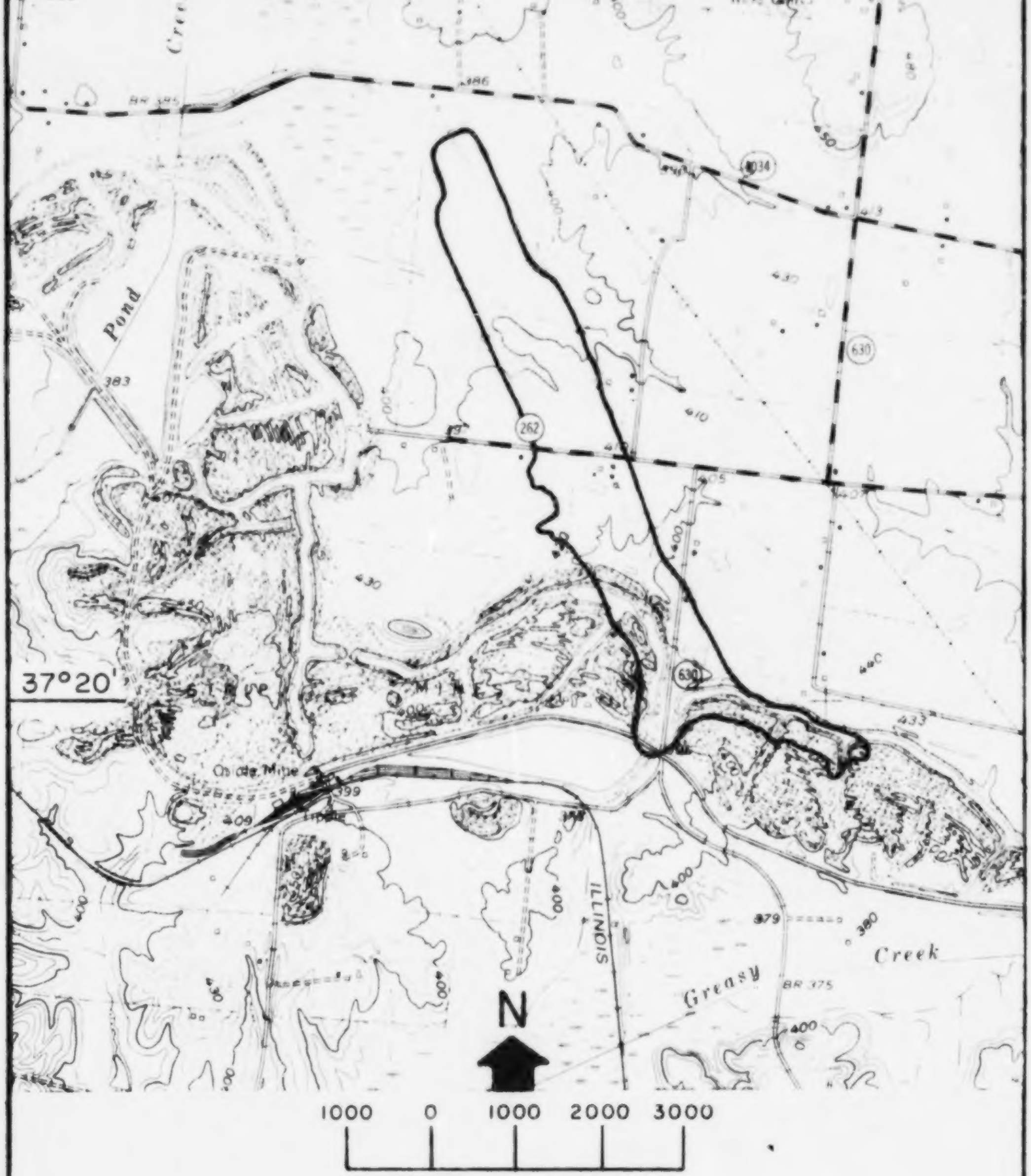
TABLE 10
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 8 ①

UNNAMED TRIBUTARY TO ISAACS CREEK NEAR BRIDGE AT RT. 70

Date	10/13/71
Flow (gpm)	900
Pht. Alkalinity ($CaCO_3$)	-
M.O. Alkalinity ($CaCO_3$)	-
Free Acidity ($CaCO_3$)	534
Total Acidity ($CaCO_3$)	1950
Conductivity (25°C) mmhos.	4530
pH (electrometrically)	2.7
Color (APHA)	-
Turbidity (JTU)	-
Calcium (Ca)	382
Magnesium (Mg)	275
Hardness ($CaCO_3$)	2086
Sulfate (SO_4)	3630
Total Iron (Fe)	355
Ferrous Iron (Fe)	16.4
Total Solids	6604
Suspended Solids	28
Dissolved Solids	6576
Settleable Solids (ml/l)	0.4
Aluminum (Al)	172
Manganese (Mn)	60
Chloride (Cl)	-
Sodium (Na)	-
Potassium (K)	-
Copper (Cu)	-
Hot Pht. Acidity ($CaCO_3$)	-

Test results reported in ppm unless otherwise noted.

① Refer to Figure 2 for location of sample point.


87°35'
37°20'
Creek
Pond
383
386
BR 385
1034
262
630
410
430
433
Colonial Mine
ILLINOIS
379
380
Greasy
Creek
BR 375
400
N
1000
0
1000
2000
3000
SCALE IN FEET

LOCATION PLAN, COLONIAL MINE - FIGURE 3

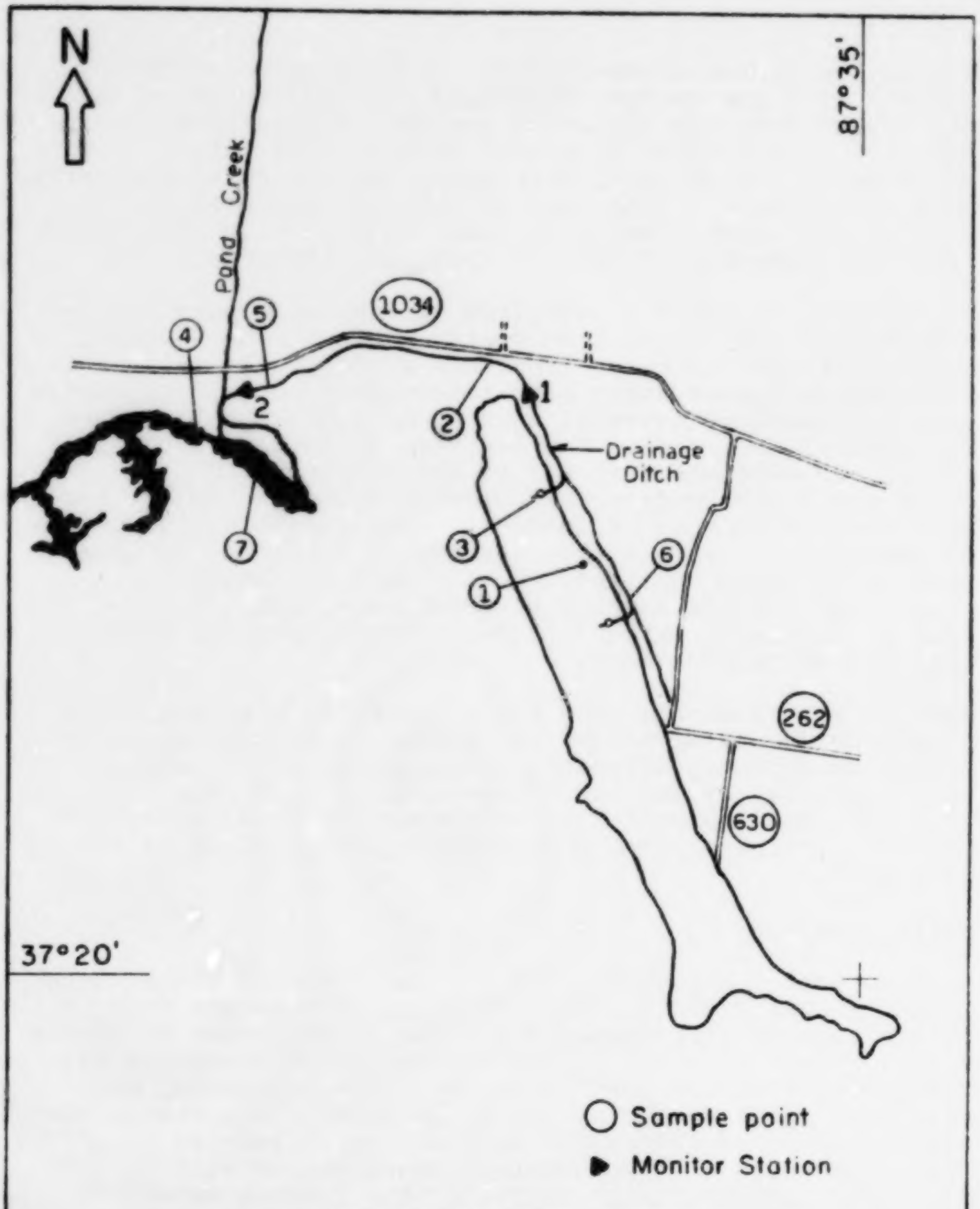
During the period of this study, pumping rates varied between 1000 gpm during relatively dry conditions up to a maximum of 5000 gpm following periods of moderately heavy rainfall. This water is pumped from the pit into a drainage ditch, which in turn flows into an abandoned strip mine impoundment. This lake is both fed and drained by Pond Creek, which flows into Clear Creek, which then drains into the Tradewater River and then into the Ohio River.

The quality of the drainage from this area is alkaline in nature with only minor iron contamination. The present quality of the discharge from this site at its confluence with the abandoned strip mine impoundment meets State water quality standards; several species of game fish have been observed at this site. Samples were collected of the influent and effluent drainage to the pit, of Pond Creek above the drainage from the Colonial strip pit and of the abandoned strip mine impoundment. The geographic locations of these sample points are illustrated in Figure 4. The results of these analyses are tabulated in Tables 11 through 17. These samples were collected periodically over a four month period and represent periods of both high and low water flows.

Data collected during this study indicates that the Vogue site provides an excellent basis for the demonstration of treatment schemes applicable to revegetation of acidic spoil material by the use of neutralized acid mine drainage; the supportive data from the Colonial site, however, indicates that additional neutralization is not warranted.

Water Resources

An important consideration in the selection of the Western Kentucky Coal Field for demonstration of mine drainage pollution control procedures was the water resources of the area. Figure 5, which is taken from "Water Resources Investigations in Kentucky" USGS 1969, shows a number of pertinent facts regarding these resources. The annual precipitation of 48 inches is important as it relates to the irrigation aspect of the control procedure as will be discussed later. The character of the surface waters in the Western Kentucky Coal Field area as predominantly sulfate bearing reflects the coal mining conditions but, more importantly, the area defined as such (under "Chemical Type of Surface Water" in Figure 5) is small enough that


N
87°35'
Pond Creek
1034
④
⑤
2
②
1
Drainage Ditch
③
⑦
①
⑥
262
630
37°20'
○ Sample point
▶ Monitor Station

COLONIAL MINE SITE

MONITOR STATION AND SAMPLE POINT LOCATIONS

FIGURE 4

TABLE 11
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 1 ①

COLONIAL STRIP PIT

Date	8/18/71
Flow (gpm)	-
Pht. Alkalinity ($CaCO_3$)	0
M.O. Alkalinity ($CaCO_3$)	40
Free Acidity ($CaCO_3$)	0
Total Acidity ($CaCO_3$)	275
Conductivity (25°C) mmhos.	5590
pH (electrometrically)	5.8
Color (APHA)	36
Turbidity (JTU)	460
Calcium (Ca)	1012
Magnesium (Mg)	2.18
Hardness ($CaCO_3$)	2440
Sulfate (SO_4)	4440
Total Iron (Fe)	210
Ferrous Iron (Fe)	207
Total Solids	6206
Suspended Solids	182
Dissolved Solids	6024
Settleable Solids (ml/l)	0.4
Aluminum (Al)	0.6
Manganese (Mn)	21
Chloride (Cl)	-
Sodium (Na)	624
Potassium (K)	26
Copper (Cu)	0.07
Hot Pht. Acidity ($CaCO_3$)	-

Test results reported in ppm unless otherwise noted.

① Refer to Figure 4 for location of sample point.

TABLE 12
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 2 ①

COLONIAL DRAINAGE DITCH APPROXIMATELY
200 YARDS DOWNSTREAM FROM HEAD OF DITCH

Date	8/18/71	10/13/71
Flow (gpm)	-	-
Pht. Alkalinity ($CaCO_3$)	0	-
M.O. Alkalinity ($CaCO_3$)	256	325
Free Acidity ($CaCO_3$)	0	-
Total Acidity ($CaCO_3$)	16.0	13.2
Conductivity (25°C) mmhos.	4400	3700
pH (electrometrically)	6.4	7.7
Color (APHA)	48	-
Turbidity (JTU)	96	-
Calcium (Ca)	528	313
Magnesium (Mg)	118	210
Hardness ($CaCO_3$)	1810	1646
Sulfate (SO_4)	2520	2150
Total Iron (Fe)	7.5	3.1
Ferrous Iron (Fe)	2.1	0.43
Total Solids	4145	3776
Suspended Solids	54	22
Dissolved Solids	4091	3754
Settleable Solids (ml/l)	0.8	<0.1
Aluminum (Al)	0.24	0.29
Manganese (Mn)	9.2	9.1
Chloride (Cl)	10.6	-
Sodium (Na)	524	-
Potassium (K)	24	-
Copper (Cu)	0.08	-
Hot Pht. Acidity ($CaCO_3$)	-	-

Test results reported in ppm unless otherwise noted.

① Refer to Figure 4 for location of sample point.

TABLE 13
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 3 ①

COLONIAL STRIP PIT DISCHARGE NEAR NORTH END OF PIT

Date	9/8/71	10/13/71	11/3/71	11/9/71
Flow (gpm)	-	3800	1200	-
Pht. Alkalinity ($CaCO_3$)	-	-	-	-
M.O. Alkalinity ($CaCO_3$)	228	380	398	374
Free Acidity ($CaCO_3$)	-	-	-	-
Total Acidity ($CaCO_3$)	8.0	12.0	12.0	10
Conductivity (25°C) mmhos.	3240	3650	3600	3610
pH (electrometrically)	7.6	7.6	7.7	7.7
Color (APHA)	35	-	-	-
Turbidity (JTU)	240	-	-	7.9
Calcium (Ca)	283	334	322	401
Magnesium (Mg)	175	165	164	177
Hardness ($CaCO_3$)	1486	1513	1477	1079
Sulfate (SO_4)	2305	2130	1950	2110
Total Iron (Fe)	370.0	0.7	4.9	2.1
Ferrous Iron (Fe)	4.36	0.06	1.6	1.4
Total Solids	3960	3727	3599	3738
Suspended Solids	219	12	55	5
Dissolved Solids	3741	3715	3544	3733
Settleable Solids (ml/l)	1.4	<0.1	<0.1	<0.1
Aluminum (Al)	195.0	0.21	0.5	0.3
Manganese (Mn)	60.0	7.0	6.2	5.9
Chloride (Cl)	-	-	-	-
Sodium (Na)	-	-	-	-
Potassium (K)	-	-	-	-
Copper (Cu)	-	-	-	-
Hot Pht. Acidity ($CaCO_3$)	-	-	-	0

Test results reported in ppm unless otherwise noted.

① Refer to Figure 4 for location of sample point.

TABLE 14
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 4 ①

POND CREEK APPROXIMATELY 600 FEET DOWNSTREAM FROM BRIDGE ON RT. 1034

Date	9/7/71
Flow (gpm)	-
Pht. Alkalinity ($CaCO_3$)	-
M.O. Alkalinity ($CaCO_3$)	15
Free Acidity ($CaCO_3$)	-
Total Acidity ($CaCO_3$)	3
Conductivity (25°C) mmhos.	1500
pH (electrometrically)	7.7
Color (APHA)	20
Turbidity (JTU)	111
Calcium (Ca)	113
Magnesium (Mg)	61
Hardness ($CaCO_3$)	533
Sulfate (SO_4)	909
Total Iron (Fe)	0.41
Ferrous Iron (Fe)	0.16
Total Solids	1529
Suspended Solids	10
Dissolved Solids	1519
Settleable Solids (ml/l)	<0.1
Aluminum (Al)	0.57
Manganese (Mn)	0.10
Chloride (Cl)	-
Sodium (Na)	-
Potassium (K)	-
Copper (Cu)	-
Hot Pht. Acidity ($CaCO_3$)	-

Test results reported in ppm unless otherwise noted.

① Refer to Figure 4 for location of sample point.

TABLE 15
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 5①

COLONIAL DRAINAGE DITCH APPROXIMATELY 20 FEET UPSTREAM FROM ITS CONFLUENCE WITH POND CREEK

Date	10/13/71	11/3/71
Flow (gpm)	-	-
Pht. Alkalinity ($CaCO_3$)	-	-
M.O. Alkalinity ($CaCO_3$)	55.6	96.0
Free Acidity ($CaCO_3$)	-	-
Total Acidity ($CaCO_3$)	7.2	12.0
Conductivity (25°C) mmhos.	2100	2610
pH (electrometrically)	7.3	7.3
Color (APHA)	-	-
Turbidity (JTU)	-	-
Calcium (Ca)	163	198
Magnesium (Mg)	105	108
Hardness ($CaCO_3$)	839	938
Sulfate (SO_4)	1130	1420
Total Iron (Fe)	0.23	0.13
Ferrous Iron (Fe)	0.15	0.10
Total Solids	1898	2452
Suspended Solids	6	3
Dissolved Solids	1892	2449
Settleable Solids (ml/l)	<0.1	<0.1
Aluminum (Al)	0.28	0.3
Manganese (Mn)	2.2	2.7
Chloride (Cl)	-	-
Sodium (Na)	-	-
Potassium (K)	-	-
Copper (Cu)	-	-
Hot Pht. Acidity ($CaCO_3$)	-	-

Test results reported in ppm unless otherwise noted.

① Refer to Figure 4 for location of sample point.

TABLE 16
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 6 ①

COLONIAL STRIP PIT DISCHARGE (NEAR MID-PIT)

Date	10/13/71	11/30/71
Flow (gpm)	1080	-
Pht. Alkalinity (CaCO$_3$)	-	-
M.O. Alkalinity (CaCO$_3$)	92.4	50.9
Free Acidity (CaCO$_3$)	-	-
Total Acidity (CaCO$_3$)	27.2	28.4
Conductivity (25°C) mmhos.	4050	4320
pH (electrometrically)	6.8	6.8
Color (APHA)	-	-
Turbidity (JTU)	-	360
Calcium (Ca)	405	560
Magnesium (Mg)	215	260
Hardness (CaCO$_3$)	1896	2466
Sulfate (SO$_4$)	2760	3457
Total Iron (Fe)	33	44
Ferrous Iron (Fe)	1.32	32.6
Total Solids	4482	5589
Suspended Solids	54	112
Dissolved Solids	4428	5477
Settleable Solids (ml/l)	<0.1	0.5
Aluminum (Al)	0.13	0.33
Manganese (Mn)	19	17
Chloride (Cl)	-	-
Sodium (Na)	-	-
Potassium (K)	-	-
Copper (Cu)	-	-
Hot Pht. Acidity (CaCO$_3$)	-	1[illegible]

Test results reported in ppm unless otherwise noted.

① Refer to Figure 4 for location of sample point.

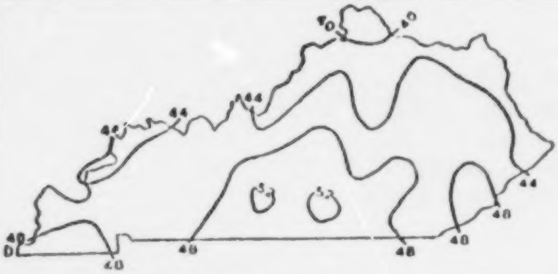
TABLE 17
WATER QUALITY ANALYSES
SAMPLE LOCATION NO. 7 ①

STRIP MINE IMPOUNDMENT
WEST OF COLONIAL PIT AREA

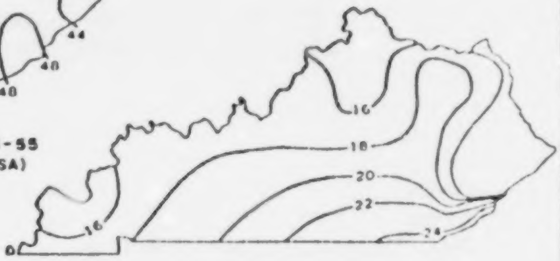
Date	1/19/72
Flow (gpm)	-
Pht. Alkalinity ($CaCO_3$)	-
M.O. Alkalinity ($CaCO_3$)	37
Free Acidity ($CaCO_3$)	-
Total Acidity ($CaCO_3$)	7
Conductivity (25°C) mmhos.	956
pH (electrometrically)	7.1
Color (APHA)	30-40
Turbidity (JTU)	2.2
Calcium (Ca)	59
Magnesium (Mg)	31
Hardness ($CaCO_3$)	275
Sulfate (SO_4)	303
Total Iron (Fe)	0.17
Ferrous Iron (Fe)	0.027
Total Solids	663
Suspended Solids	2
Dissolved Solids	661
Settleable Solids (ml/l)	<0.1
Aluminum (Al)	<0.1
Manganese (Mn)	0.49
Chloride (Cl)	-
Sodium (Na)	-
Potassium (K)	-
Copper (Cu)	-
Hot Pht. Acidity ($CaCO_3$)	-

Test results reported in ppm unless otherwise noted.

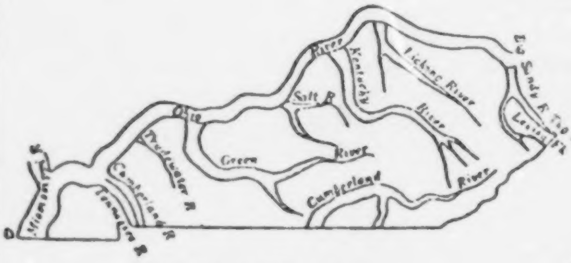
① Refer to Figure 4 for location of of sample point.


40
40
44
44
44
44
52
52
48
48
48
40
40
48
D

MEAN ANNUAL PRECIPITATION IN INCHES 1931-55
(DATA FROM US WEATHER BUREAU-ESSA)


16
18
20
22
24
16
D

AVERAGE ANNUAL RUNOFF IN INCHES

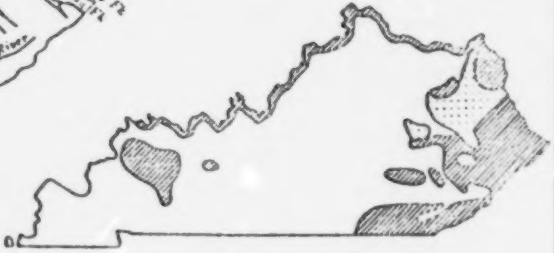

Ohio River
Kentucky River
Licking River
Big Sandy R
Tug Fk
Levisa Fk
Salt R
Green River
Cumberland River
Tradewater R
Cumberland R
Tennessee R
Mississippi R
D

MEAN DISCHARGE, CFS

100 1000 5000 15,000	25,000 100,000 200,000 500,000

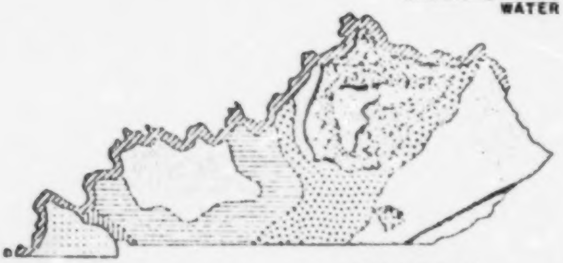
WIDTH OF RIVER INDICATES MEAN DISCHARGE

MEAN DISCHARGE OF MAJOR RIVERS, IN CUBIC FEET PER SECOND



☐ BICARBONATE ▨ SULFATE ░ CHLORIDE

CHEMICAL TYPE OF SURFACE WATER



MOST WELLS YIELD ENOUGH WATER FOR DOMESTIC USE

▦ SANDSTONE AND SILTSTONE

░ LIMESTONE

▥ SAND

▤ LIMESTONE AND SANDSTONE

WELLS YIELD 100 GALLONS OR MORE PER MINUTE

▨ SAND AND GRAVEL

░ SAND BENEATH SURFACE FORMATIONS

ABOUT HALF THE WELLS YIELD ENOUGH WATER FOR DOMESTIC USE

☐ LIMESTONE AND SHALE

▩ SILTSTONE

TYPE AND YIELD OF AQUIFERS

WATER RESOURCES DATA - FIGURE 5

successful treatment procedures may ultimately restore quality to that of surrounding areas (headwaters) which are predominantly bicarbonate containing.

As indicated by Figure 5, the quality of surface streams uncontaminated by mine drainage in western Kentucky reflects the limestone common to the area and particularly to the headwaters. Table 18 shows the quality of the Green River at Bowling Green, Kentucky, which is upstream of surface coal mining activities and is typical of the natural surface quality. Also shown in Table 18 is an analysis of the Pond River near Sacramento, Kentucky, just north and east of Madisonville. This is a point downstream of heavily mined areas, including those of Site No. 1 and Site No. 2 previously mentioned. Also listed in Table 18 is an analysis of the Tradewater River at Olney, Kentucky, which is west and slightly south of Madisonville, but downstream of considerable surface mining activity. The drainage from Site No. 3 and, at times, Site No. 4 enters downstream of Olney.

There is very little published data available on the quality of the streams draining the particular active sites under consideration. Stream monitoring stations should be installed to provide a continuous record of the surface water quality in order to establish the data required to adequately evaluate the effectiveness of the demonstration project.

Most of the surface streams draining the western Kentucky coal region are contaminated with acid mine drainage. Clear Creek, for example, originates in the south-central portion of Hopkins County near Madisonville. It flows in a west-northwesterly direction to its confluence with the Tradewater River at the Hopkins and Webster County line. Two of the major tributaries of Clear Creek are Pond Creek and Greasy Creek, into which the drainages discharge from Site No. 4, Colonial Mine.

There are no fish in either Clear Creek or its tributaries because of acid mine drainage. Clear Creek has a pH range of 2.5 to 4.0. Apparently, many of the older open pits are self-contained and contribute little to downstream pollution problems. It is estimated, however, that runoff occurs on roughly 25 percent of the strip mine spoil areas. Isaacs Creek, which receives the drainage from the Vogue strip mine, exhibits similar quality characteristics.

TABLE 18
SURFACE WATER QUALITY

	Green River at Bowling Green, Ky. (Warren County)		Pond River near Sacramento, Ky. (McLean County)		Tradewater River at Olney, Kentucky (Caldwell County)	
	Dec/1967	Feb/1969	Oct/1967	Oct/1968	Oct/1967	Nov/1968
Total Iron (Fe)	0.12	0.12	7.1	40	0.02	0.1
Aluminum (Al)	-	-	-	55	5.2	16
Manganese (Mn)	0.18	0.02	11	19	13	18
Calcium (Ca)	44	38	160	238	-	140
Magnesium (Mg)	9	6.6	81	158	-	92
Sodium (Na)	4.5	4.6	55	76	-	18
Bicarbonate (HCO_3)	130	122	0	0	2	0
Sulfate (SO_4)	36	18	888	1790	528	860
Chloride (Cl)	8	9	28	22	6	10
Hardness ($CaCO_3$)	147	122	733	1240	504	729
Conductivity(25°C)mmhos	306	269	1810	3200	966	1440
Dissolved Solids	177	142	1350	2470	822	1260
pH	7.6	7.4	3.3	2.8	4.6	4.2

Test results reported in mg/l unless otherwise indicated.

Samples collected periodically throughout the course of this study indicate that the discharge water from the Vogue mine site is highly acid and would provide an excellent basis for a demonstration of treatment schemes applicable to area type surface mining techniques. The discharge from the Colonial mine site is alkaline in nature and would not be representative of typical acid mine drainage conditions for the demonstration of a hydrated lime neutralization plant; the quality of this water would, however, provide an excellent source of water for irrigation purposes.

Social and Economic Environment

The mine sites discussed are in two adjacent counties and are both in the immediate vicinity of the City of Madisonville. For purposes of an analysis of the social and economic factors inherent in the area of the selected sites, census data has been reviewed with respect to the state, counties involved, and the City of Madisonville. Comparisons between 1960 and 1970 figures indicate that major trends determined within the Commonwealth are as follows:

1. Kentucky's population increase has lagged behind the national average.

2. A larger portion of the Commonwealth's population has become urbanized.

3. Kentucky has fewer people in the working class age group of 20-64 years of age than the national average.

The counties and city aforementioned are definitely following the statewide trend, in that the City of Madisonville has experienced a 16.9% increase in population between census surveys while Hopkins and Muhlenberg Counties have experienced small percentage decreases in population over the same period. Muhlenberg County, site of the Vogue Mine, experienced a shift in population by displaying an increase in urban population and a decrease in rural population.

Pertinent facts (1970) on population density for the areas of the demonstration sites are as follows:

Muhlenberg County

481 square miles land area
27,537 population
57.2 people/square mile

Hopkins County

553 square miles land area
38,167 population
69.0 people/square mile

Statistics (1960) on the population in the Commonwealth reveal that half of the state's employed workers are in blue-collar occupations, the number of adults completing one or more years of college is lower than the national average, and nearly four out of ten families have incomes of $3,000 or less. This is significant since the state does not experience a high influx of new residents and those that are native born remain in the state of their birth, as evidenced by the figures on Hopkins (88.9%) and Muhlenberg (92.9%) Counties. People in the area are definitely dependent upon employment in the vicinity of their home since low percentages of the work force work outside the county of their residence (8.4% in Hopkins County and 11.8% in Muhlenberg County).

Over 50% of the population in Muhlenberg and Hopkins Counties is in the age bracket of 18 to 64, eligible to be a part of the work force. However, state records indicate that the largest segment of the population is in the age bracket 44 to 64, which also coincides with the largest segment of the working force. This part of the population is significant since, of the people 25 years old or older, only a third have completed 4 years of high school and the median years of school completed for the average individual is only 8.5 at best.

The factors of minimal education, dependence on employment in the vicinity of the home, predominance of employment in blue-collar positions are significant factors indicating the potential of the work force. This is further supported by the high unemployment in the counties (5% in Hopkins and 9.5% in Muhlenberg) and the low median income of the average laborer ($4,044 in Hopkins and $3,355 in Muhlenberg). Workers are dependent on manufacturing industries, agriculture, construction and mining as the chief areas of employment. The need for increased job opportunities is critical from the standpoint that the median age of the public is 27.6 and a significant segment of the population is married and has children of elementary school age. These young families, as well as the older segment of the population approaching retirement, require a sufficient income on which to survive and are heavily dependent on the industry established in the Commonwealth.

Water may be Kentucky's primary industrial resource for the future; therefore, it is important that everything possible be done to maintain or improve the quality of the waters of the Commonwealth so that a sufficient quantity of good quality water is available for existing and potential industrial consumption. According to information available on water sources and consumption in the Commonwealth, 83.6% of the water sources in the Western Coal Field are attributed to surface water, of which 78.1% of the supply is put to industrial use. To assure the continuous supply of water in the quantity and quality required for such use, the Commonwealth has laws and regulatory agencies which exist to safeguard streams against pollution, continually monitor water quality and quantity of Commonwealth streams, and allocate water supply usage in the Commonwealth.

The provision of a good supply of water to encourage industrial investment in the Commonwealth will serve as a major factor in providing more job opportunities. The economic development so stimulated and the jobs created will serve to encourage a larger population growth in the Commonwealth. In general, population increases are being experienced around urban centers at the expense of rural areas of the Commonwealth. Although a reversal in this trend is not expected, increased water usage is anticipated in rural areas for irrigation of croplands. Therefore, the use of treated water as a significant feature of the demonstration project will provide valuable results toward the overall improvement of Commonwealth waters for all use requirements.

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SECTION VI

PRELIMINARY ENGINEERING

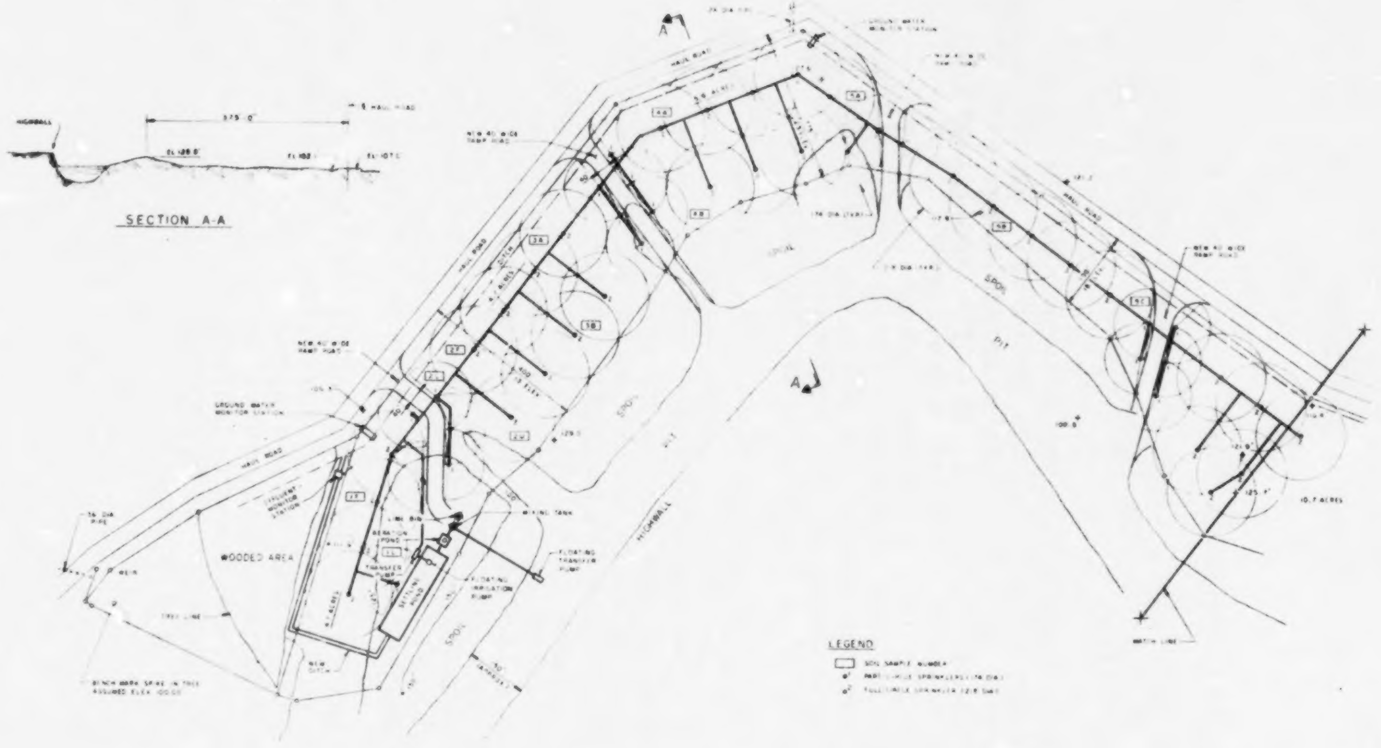
Abatement Project Description

As previously mentioned, two sites were selected for further investigation, namely the No. 1 Vogue and the No. 4 Colonial sites.

The Vogue mine, operated by the Peabody Coal Company, is located in Muhlenberg County, Kentucky. Approximately 50% of the permit area has been mined to date; with the exception of the existing pit area, the spoil banks have been regraded to near original contour conditions. While the mine has been inactive throughout the course of this study, present plans call for the resumption of stripping operations during the spring of 1974. At that time, mining will begin in the northern section of the pit and progress in a southwesterly direction.

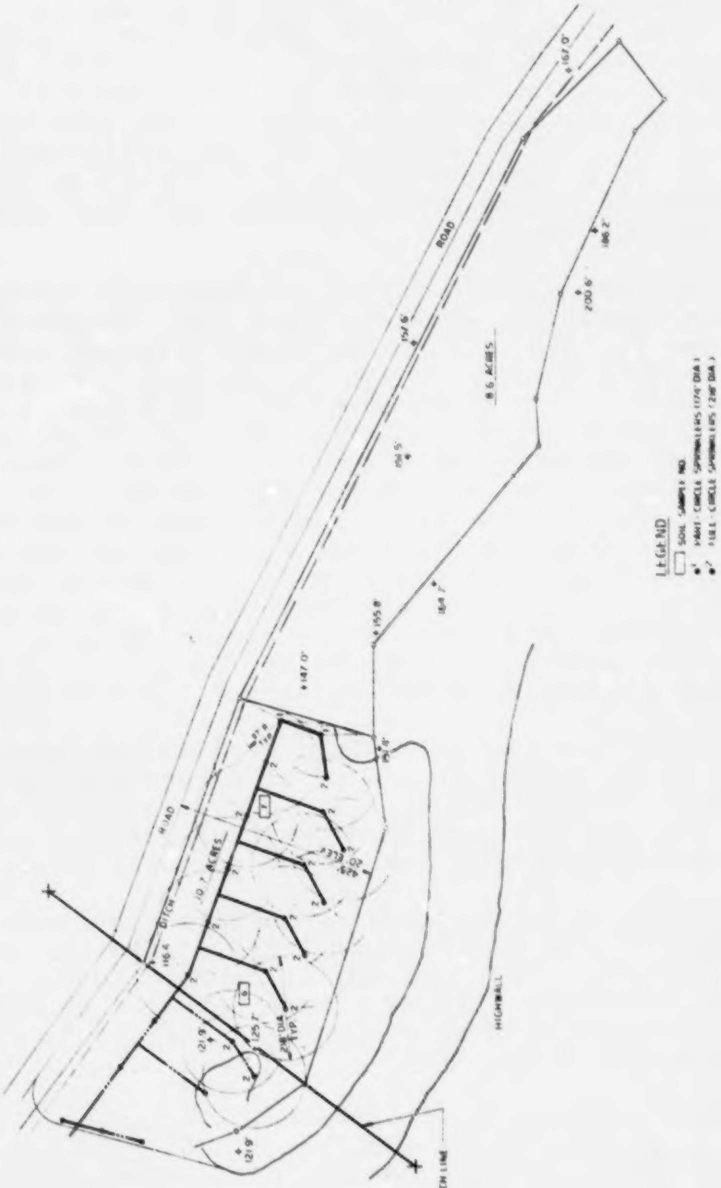
The area initially allocated for the demonstration site consisted of approximately 35 acres beginning at the north end of the pit (refer to Figures 6 and 7). Since the coal seam generally dips to the north at this site and all drainage eventually exits at the north end of the pit, the pumping facilities and treatment plant would be located in this area to eliminate excessive pumping distances and interferences with mining operations. The extreme southern portion of the demonstration area (5 acres) could be used as a control test plot in which surface preparation, pretreatment and planting would be identical to the remaining demonstration area, the only difference in treatment being that this area would not be irrigated.

Soil samples were taken in some detail at the Vogue mine site as shown on the map of the area (refer to Figures 6 and 7). The entire area showed signs of acidic materials, including isolated and small severely acid spots. The 14 samples taken represent approximately two acres each, and each sample was composed of approximately eight cores taken at a depth of 0-8 inches.


HIGHWALL
375'-0"
℄ HAUL ROAD
EL 128.0'
EL 102
EL 107
SECTION A-A
A
HAUL ROAD
DITCH
4.7 ACRES
3.6 ACRES
NEW 40' WIDE RAMP ROAD
GROUND WATER MONITOR STATION
EFFLUENT MONITOR STATION
36" DIA PIPE
WEIR
WOODED AREA
TREE LINE
BENCH MARK SPIKE IN TREE ASSUMED ELEV 100.00
NEW DITCH
LIME BIN
AERATION POND
TRANSFER PUMP
SETTLING POND
FLOATING IRRIGATION PUMP
FLOATING TRANSFER PUMP
MIXING TANK
SPOIL
PIT
HIGHWALL
2A
2B
2C
2D
2E
2F
3A
3B
4A
4B
5A
5B
5C
100.0'
121.0'
125.1'
10.7 ACRES
MATCH LINE
LEGEND
SOIL SAMPLE NUMBER
PART CIRCLE SPRINKLERS (174' DIA.)
FULL CIRCLE SPRINKLER (218' DIA.)

VOGUE PLOT PLAN - SHEET 1

FIGURE 6


ROAD
ROAD
DITCH
10.7 ACRES
8.6 ACRES
HIGHWALL
MATCH LINE
LEGEND
SOIL SAMPLE NO.
PART-CIRCLE SPRINKLERS (174' DIA.)
FULL-CIRCLE SPRINKLERS (218' DIA.)
167.0'
186.2'
200.6'
157.6'
156.5'
155.8'
164.7'
147.0'
116.4'
121.9'
125.7'
121.9'

VOGUE PLOT PLAN - SHEET 2

FIGURE 7

The samples were returned to the laboratory, dried in a 60°C oven and ground to pass a 2 mm screen. Analyses for pH, lime requirement, phosphorus and potassium were run by the Soil Testing Laboratory at the University of Kentucky. Four of the most acid materials were shaken with 0.04N $CA(OH)_2$ for one day and pH was determined on the suspensions. (This was done to verify the Soil Testing Laboratory lime requirement test for the most severely acid areas.) Electrical conductivity was determined on all materials in a 2:1 water-spoil ratio using an Industrial Instruments Bridge and a conductivity cell with a cell constant of 1.0.

The results of the pH, electrical conductivity, phosphorus and potassium tests are shown in Table 19. In general the pH values in samples from the Vogue site are rather low, but the extreme ends (1 and 7) are much less acid than the middle. Area 4 was especially acid and so was area 6 (refer to Figures 6 and 7). The electrical conductivity did not appear to be a serious problem except in area 4. Even here, it is doubtful that it will prevent plant growth after winter rains remove some of the salt. Phosphorus extractable by NH_4F-HCl was very low for all samples. This usually is the case in mine spoils and nothing out of the ordinary was encountered. Potassium was on the borderline in all of the samples from the Vogue site. However, except for samples 2F, 4B and 6, it is unlikely that potassium is deficient for plant growth.

The lime requirement was determined for all the materials sampled using the change in the pH of a buffered salt as the indicator. Values obtained are shown in Table 19 and range from one ton per acre to eight tons per acre of the Vogue mine and from 0 to 1 ton on the Colonial mine.

Because of the extreme variability in lime requirement on the Vogue mine spoils and because later irrigation can be used to supplement problem areas, it appears that a general agricultural limestone rate of 5 tons per acre should be used as a treatment as soon as the land surface is reformed for irrigation.

Since phosphorus levels were very low, 200 lbs. of P_2O_5 per acre will be applied (about 425 lbs. of 46% P_2O_5 per acre) at the Vogue site. Because potassium is somewhat low, 100 lbs. of 60% K_2O should be applied in order to assure adequate growing conditions.

TABLE 19
CHEMICAL CHARACTERISTICS OF THE SPOIL MATERIALS FROM THE VOGUE AND COLONIAL MINES
(Sampled November 30, 1971)

Location of Spoil Material*	pH	Conductivity** mhos/cm^2	P lbs/A	K lbs/A	Lime*** Requirement Tons/Acre
Vogue Mine:					
1 F	5.3	1.35	5	136	1.0
L	5.7	2.50	1	135	1.0
2 F	3.3	3.25	6	94	7.0
U	4.5	2.70	2	122	1.0
L	3.8	3.10	3	122	4.0
3 F	3.4	3.15	7	113	7.0
B	4.5	2.50	2	144	1.0
4 A	3.1	4.00	8	106	8.0
B	3.0	3.80	5	85	7.0
5 A	4.6	3.30	2	115	1.0
B	3.9	3.40	4	117	4.0
C	4.5	3.40	2	120	1.0
6	3.2	3.00	4	81	8.0
7	5.1	2.70	2	140	1.0
Colonial Mine:					
1	7.7	1.40	1	315	0
2	6.7	1.90	2	330	0
3	8.1	1.05	1	312	0
4 (Vegetated)	4.9	1.05	4	119	1.0

* Refer to Figures 6 and 7

** 10 g soil: 20 ml H_2O

*** Agricultural Limestone

All spoil material is generally low in nitrogen and this element is required in rather large amounts for plant growth. In view of this, the Vogue site should be fertilized at the rate of 100 lbs. of nitrogen per acre (300 lbs. of ammonium nitrate). All these recommendations are summarized in Table 20.

Water samples were collected and flow measurements were made of the pit influent and effluent drainage and of Isaacs Creek above and below the drainage from the Vogue mine site at regular intervals throughout the course of this study. The results of the analyses of these samples can be seen in Tables 3 through 10.

On the basis of the pit effluent water analyses and observed flow rates, (refer to Table 21), a conventional acid mine drainage treatment plant is proposed to treat the total pit effluent to a level acceptable for discharge to a receiving stream. The treatment plant will be designed in such a manner as to permit the neutralized, oxidized discharge from the process to either be used as irrigation water on the prepared spoil banks or to be clarified in temporary settling ponds for ultimate discharge to a receiving stream. A plot plan of the proposed treatment plant/irrigation system is shown in Figures 6 and 7.

The neutralization plant would employ standard "off the shelf" equipment. Such equipment is suitable for use with either hydrated lime or pulverized limestone. While limestone has been shown to be less effective than hydrated lime (50-75%), the unreacted limestone would have a residual benefit on the spoil. Limestone consumption has been estimated at 1000 pounds per hour for treatment of the maximum flow expected from the Vogue mine site. A flow diagram of the proposed treatment facilities can be seen in Figure 8. The entire set of equipment would be constructed in modular fashion for easy movement from site to site. A self-contained diesel electric power plant would be one of the modular units and would supply all power for the pumps and control equipment.

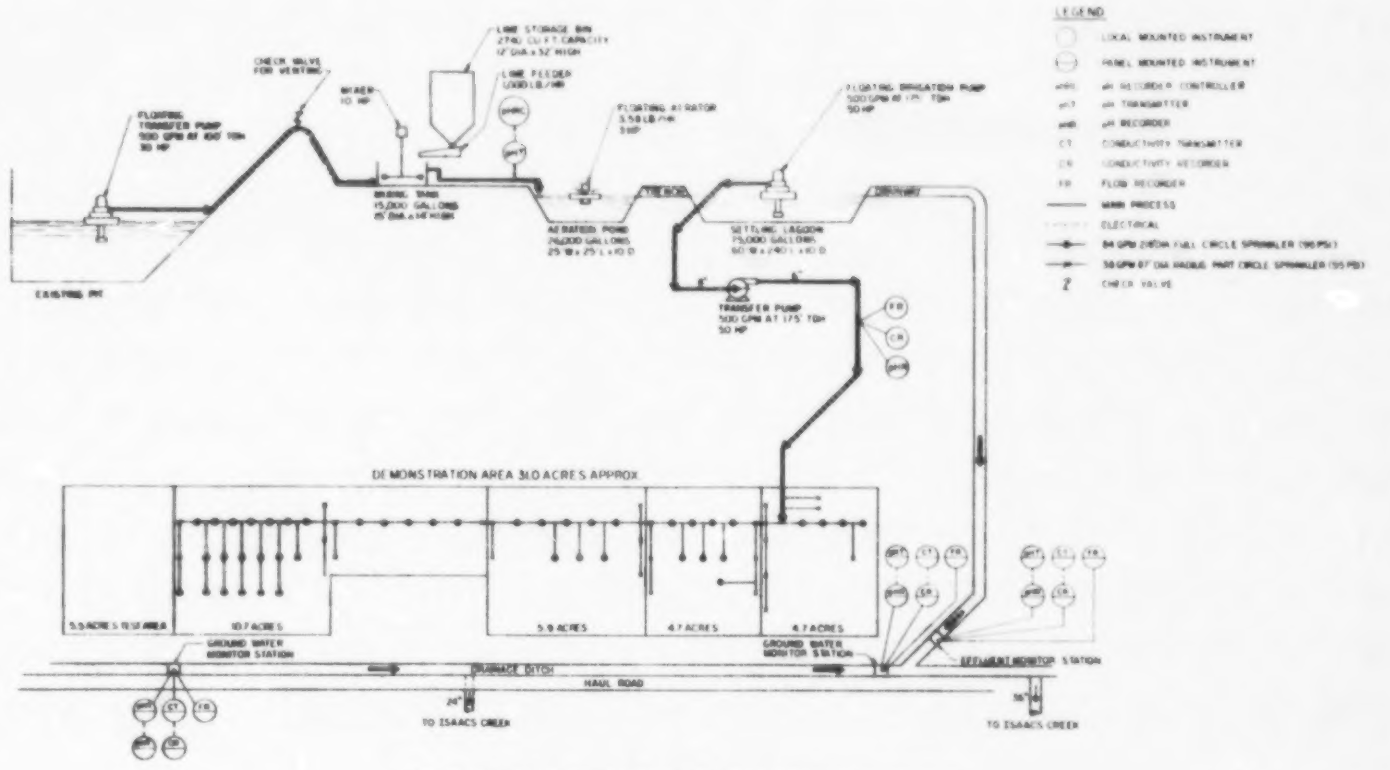
During those months when irrigation may be employed almost continuously in July, August, September and October, records indicate an average monthly 3.5" rainfall (refer to Table 22). This amount deducted from an average of 0.25" per day for evapo-transpiration gives an average of 4" of water per acre per month for irrigation. On this basis, the 25 acres available for irrigation at the Vogue site would require an average of 275 gpm operating eight hours per day five days

TABLE 20
RECOMMENDED RATES OF LIME, FERTILIZER AND SEED FOR VOGUE AND COLONIAL SPOIL AREAS

Location	Tons Lime Per Acre	Lbs. Fertilizer Elements/Acre			Lbs. Seed per Acre			
		N	P_2O_5	K_2O	Kentucky Fescue	Korean Lespedeza	Red Clover	Ladino Clover
Vogue Mine	5	100	200	100	10	10	10	0
Colonial Mine	0	100	200	200	10	0	10	5

TABLE 21
VOGUE PIT DISCHARGE
WATER ANALYSES TABULATION
SAMPLE LOCATION V-7

	9/10	10/13	11/3	11/9	11/30	1/19	Max.	Min.	Ave.
Flow (gpm)	600	175	140	-	-	-	600	140	305
Pht. Alkalinity ($CaCO_3$)	0	-	-	-	-	-	-	-	-
M.O. Alkalinity ($CaCO_3$)	0	-	-	-	-	-	-	-	-
Free Acidity ($CaCO_3$)	440	415	673	602	680	201	680	201	502
Total Acidity ($CaCO_3$)	810	1280	1438	1397	1230	555	1438	555	1118
Conductivity (25°C) mmhos.	3760	4070	4110	4050	3720	2700	4110	2700	3735
pH (electrometrically)	2.9	2.8	2.8	2.8	2.7	2.9	2.9	2.7	2.8
Color (APHA)	60	-	-	-	-	30-40	60	30-40	47.5
Turbidity (JTU)	1.4	-	-	29.0	6.4	12.0	29.0	1.4	12.2
Calcium (Ca)	330	394	429	390	390	262	429	262	366
Magnesium (Mg)	195	235	256	234	230	160	256	160	218
Hardness ($CaCO_3$)	1625	1951	2123	1934	1918	1311	2123	1311	1810
Sulfate (SO_4)	3081	3020	3290	3180	2992	1723	3290	1723	2881
Total Iron (Fe)	98	165	130	108	110	102	165	98	119
Ferrous Iron (Fe)	4.4	8.32	2.97	2.9	3.07	7.03	8.32	2.9	4.78
Total Solids	4918	5157	4616	5163	4885	2710	5163	2710	4575
Suspended Solids	29	53	1	2	25	18	53	1	21
Dissolved Solids	4889	5104	4615	5161	4860	2692	5161	2692	4554
Settleable Solids (ml/l)	0.2	1.6	<0.1	<0.1	0.5	<0.1	1.6	<0.1	0.38
Aluminum (Al)	130	120	130	124	10	69.1	130	10	97.2
Manganese (Mn)	40.0	50.0	48.5	51.7	48.0	33.4	51.7	33.4	45.3


LINE STORAGE BIN
2740 CU FT CAPACITY
12' DIA x 32' HIGH
CHECK VALVE
FOR VENTING
MIXER
10 HP
LINE FEEDER
1000 LB/HR
FLOATING AERATOR
3.5 LB/HR
5 HP
FLOATING IRRIGATION PUMP
500 GPM AT 175' TDH
50 HP
FLOATING
TRANSFER PUMP
500 GPM AT 100' TDH
30 HP
MIXING TANK
15,000 GALLONS
15' DIA x 14' HIGH
AERATED POND
26,000 GALLONS
25' W x 25' L x 10' D
SETTLING LAGOON
75,000 GALLONS
60' W x 240' L x 10' D
EXISTING PIT
TRANSFER PUMP
500 GPM AT 175' TDH
50 HP
FR
CR
pHR
LEGEND
LOCAL MOUNTED INSTRUMENT
PANEL MOUNTED INSTRUMENT
pHRC pH RECORDER CONTROLLER
pHT pH TRANSMITTER
pHR pH RECORDER
CT CONDUCTIVITY TRANSMITTER
CR CONDUCTIVITY RECORDER
FR FLOW RECORDER
MAIN PROCESS
ELECTRICAL
84 GPM 280' DIA FULL CIRCLE SPRINKLER (90 PSI)
38 GPM 87' DIA RADIUS PART CIRCLE SPRINKLER (95 PSI)
CHECK VALVE
DEMONSTRATION AREA 31.0 ACRES APPROX
5.5 ACRES TEST AREA
10.7 ACRES
5.9 ACRES
4.7 ACRES
4.7 ACRES
GROUND WATER
MONITOR STATION
GROUND WATER
MONITOR STATION
EFFLUENT MONITOR STATION
DRAINAGE DITCH
HAUL ROAD
20"
TO ISAACS CREEK
36"
TO ISAACS CREEK
pHT
CT
FR
pHR
CR

VOGUE MINE - PROCESS FLOW & INSTRUMENTATION DIAGRAM

FIGURE 8

TABLE 22
TABULATION OF RAINFALL DATA
MADISONVILLE, KY. - HOPKINS COUNTY
1960 THROUGH 1971

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YR.TOT.
1960	2.43	2.93	2.70	2.73	2.58	5.47	5.50	0.83	1.65	1.64	4.13	3.70	36.29
1961	2.58	5.51	5.13	5.61	6.56	2.86	7.17	3.53	1.94	3.48	5.79	4.13	54.29
1962	4.31	7.06	4.13	2.55	4.85	3.08	2.44	5.71	5.59	2.51	2.10	2.07	46.40
1963	0.64	0.96	9.71	1.31	3.77	1.99	2.92	2.33	0.40	0	1.38	0.88	26.29
1964	2.49	2.41	14.68	3.31	3.95	2.22	3.86	2.82	5.84	0.29	3.44	5.15	50.46
1965	4.30	4.15	7.25	3.88	1.65	2.96	2.91	2.37	6.07	1.84	2.45	0.86	40.69
1966	4.67	4.04	1.18	9.45	6.19	1.62	0.95	3.71	4.60	2.51	2.87	4.72	46.51
1967	2.21	2.59	3.11	2.92	7.69	4.95	5.99	2.33	3.94	3.49	3.29	5.47	47.98
1968	1.91	1.93	4.84	5.32	6.25	1.83	3.96	3.08	3.84	1.19	4.26	4.16	42.57
1969	6.47	1.69	2.98	5.40	3.48	13.86	4.31	3.48	2.70	2.63	4.93	4.73	57.16
1970	0.69	4.11	4.58	9.03	2.28	5.18	4.18	3.23	0.91	7.73	2.27	4.87	49.06
1971	4.50	8.19	1.88	1.78	3.20	3.89	4.96	1.38	3.36	1.98	1.91	4.26	41.29
TOT.	37.20	45.57	62.17	53.29	52.45	49.91	49.65	34.80	40.84	29.29	38.82	45.00	538.99
AVE.	3.10	3.80	5.18	4.44	4.37	4.16	4.14	2.90	3.40	2.44	3.24	3.75	44.92

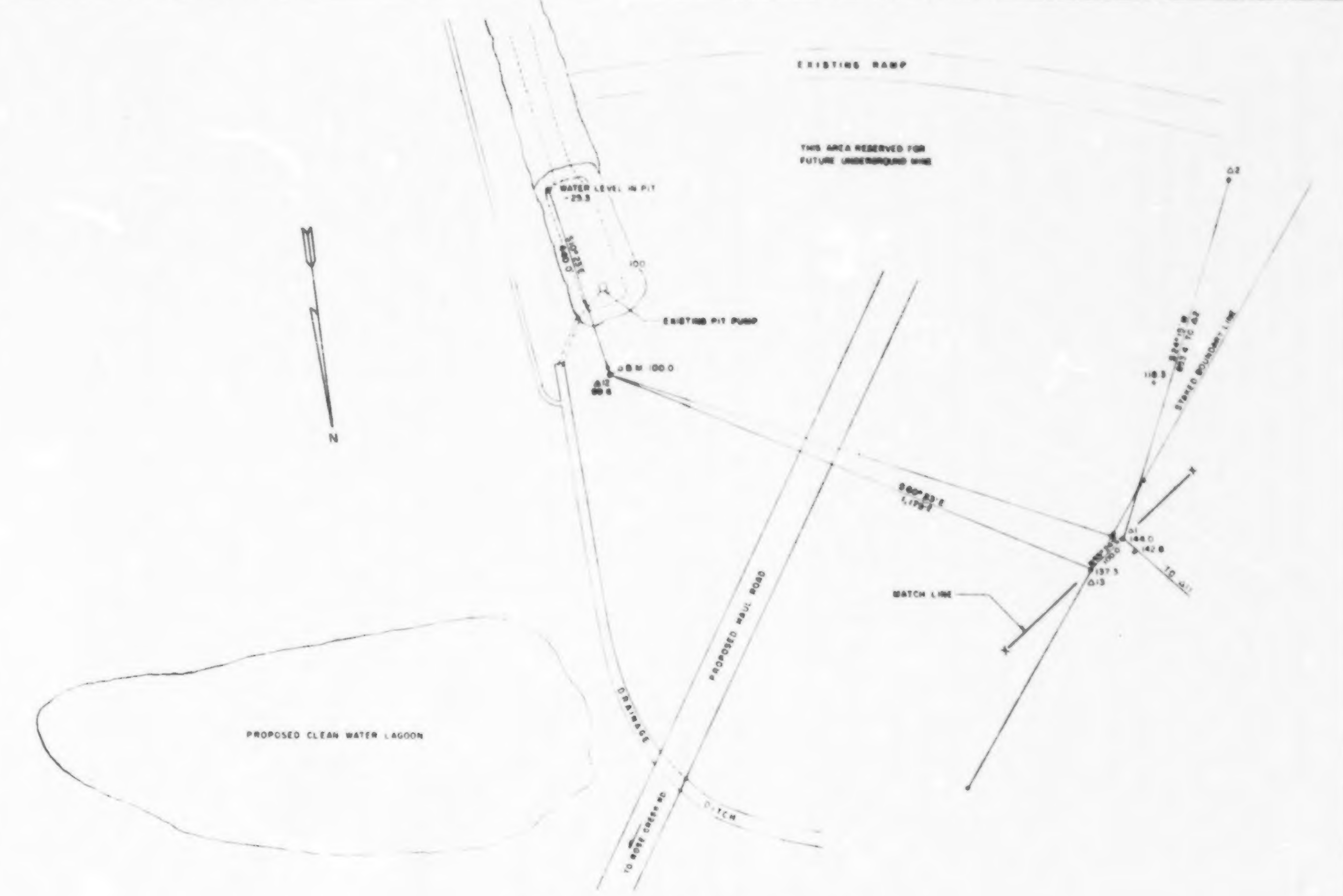
per week. After germination, the system can be scheduled to supply up to 0.50" of water per day without damage to vegetation, providing the spoil is capable of absorbing this amount of water without becoming saturated. By so stressing the system, the amount of total dissolved solids entering the receiving stream could be significantly reduced or possibly eliminated depending on the volume of water available for irrigation.

The Colonial mine, operated by the Pittsburg & Midway Coal Mining Company, is located in Hopkins County, Kentucky. Approximately 90% of the permit area has been mined to date. With the exception of the existing pit area, the spoil banks have been regraded to near original permit conditions. Due to the dip of the coal and the increasing amount of overburden which must be removed to gain access to the coal seam, surface mining operations will be discontinued in the near future and a deep mine will be developed near the northeastern end of the present pit area.

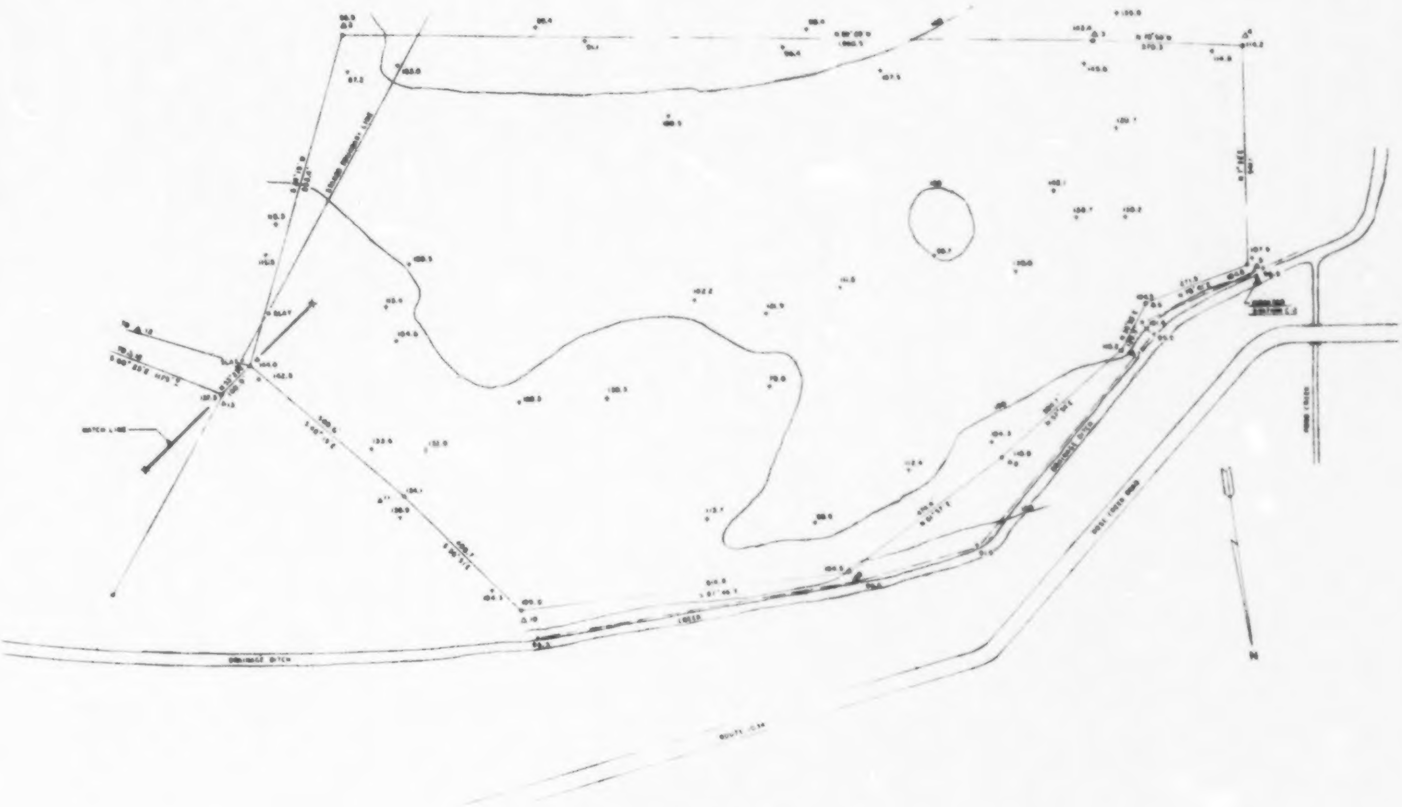
The area initially allocated for the demonstration site consisted of approximately 60 acres near the northwest portion of the present pit area (refer to Figures 9 and 10). Of the total area available, preliminary plans called for a 30-acre plot to be used to demonstrate the effectiveness of irrigation, while an additional 10-acre plot was to be used as a control area in which surface preparation, pretreatment and planting would be identical to the demonstration area.

Only four soil samples were taken at the Colonial mine site, since it was evident that acidic materials were not a serious problem. Three of the samples were taken from a fairly fresh, rocky material that had a sparse stand of sweet clover. One sample was taken from an area having a good stand of fescue. The material on which the fescue was growing was quite sandy and apparently had washed in from the surrounding higher points. The fact that volunteer vegetation was taking over the Colonial site indicates, better than any other measure, the absence of acidic materials on the surface.

The samples were returned to the laboratory and analyzed as previously described. The results of the pH, electrical conductivity, phosphorus and potassium tests are shown in Table 19.


EXISTING RAMP
THIS AREA RESERVED FOR
FUTURE UNDERGROUND MINE
WATER LEVEL IN PIT
-25.3
S10° 23' E
680.0'
100
EXISTING PIT PUMP
BM 100.0
Δ12
99.6
N
S60° 23' E
1,175.2'
Δ2
118.3
STAKED BOUNDARY LINE
Δ1
144.0
142.8
TO Δ11
137.5
Δ13
MATCH LINE
PROPOSED HAUL ROAD
DRAINAGE
DITCH
TO ROSE CREEK RD
PROPOSED CLEAN WATER LAGOON

COLONIAL SURVEY PLAN - SHEET I
FIGURE 9



COLONIAL SURVEY PLAN - SHEET 2

FIGURE 10

The pH values for the Colonial mine samples are very satisfactory except for sample 4. The value for sample 4 may be caused by some surface acid runoff since the appearance of the fescue grass was vigorous. Conductivities in all the Colonial samples were low. The potassium level was very high in samples 1 through 3, while sample 4 was marginal. Potassium should be adequate for plant growth at this site.

Since phosphorus levels were very low, 200 lbs. of P_2O_5 per acre would be required (425 lbs. of 46% P_2O_5 per acre) at the Colonial site. As previously mentioned, nitrogen is generally low in all spoil material; therefore, the Colonial site would also require approximately 100 lbs. of nitrogen per acre (300 lbs. of ammonium nitrate).

Planting would be in the late spring and would be assisted by irrigation to assure germination and survival during the sensitive seedling stage.

Water samples were collected and flow measurements were made of the pit influent and effluent drainage at regular intervals throughout the course of this study. Water samples were also collected of Pond Creek near its confluence with the Colonial mine discharge and of the strip mine impoundment which is fed by Pond Creek and the Colonial mine discharge. The results of the analyses of these samples can be seen in Tables 11 through 17. As is evidenced by the quality of the effluent water near its point of entry into the receiving stream (Sample Location No. 5, Table 15), the discharge from the Colonial mine site is within the Kentucky state discharge regulations and does not appear to require any additional treatment. While this appears to be contradictory to the results of the preliminary analysis reported in Table 2, it should be noted that the initial sampling was done near the southern portion of the pit area (site of the active operations at that time) and subsequent sampling was done at the northern end of the pit. It should also be pointed out that the actual quality of the pit water at the point of discharge does not meet Kentucky state discharge standards (refer to Tables 23 and 24). If property limitations were such that this discharge did not receive the benefit of settling afforded by the extensive drainage system, this effluent water would require treatment prior to its discharge into any receiving stream.

TABLE 23
COLONIAL PIT DISCHARGE
WATER ANALYSES TABULATION
SAMPLE LOCATION C-3

	9/8	* 10/13	* 11/3	* 11/9	SMR-Rg-11 Wtr.Qual.	Ky.Stream Stds.	Max.	Min.	Ave.
Flow (gpm)		3800	1200				3800	1200	2500
pH (electrometrically)	7.6	7.6	7.7	7.7	≥6.0 ≤9.0	≥5.0 ≤9.0	7.7	7.6	7.65
M.O. Alkalinity ($CaCO_3$)	228	380	398	374			398	228	345
Free Acidity ($CaCO_3$)									
Total Acidity ($CaCO_3$)	8	12	12	10	≤Tot.Alk.		12	10	10.5
(25°C) Conductivity mmhos	3240	3650	3600	3610		≤1200 Ave. ≤1600 Max.	3650	3240	3525
Turbidity (JTU)	240			7.9	≤150 JTU		240	7.9	124
Calcium (Ca)	283	334	322	401			401	283	335
Magnesium (Mg)	175	165	164	177			177	164	170
Hardness ($CaCO_3$)	1486	1513	1477	1079			1513	1079	1388
Sulfate (SO_4)	2305	2130	1950	2110			2305	1950	2124
Total Iron (Fe)	370	0.7	4.9	2.1	≤7.0		370	1	94.4
Ferrous Iron (Fe)	4.36	0.06	1.6	1.4			4.36	0.06	1.85
Total Solids	3960	3727	3599	3738			3960	3599	3756
Suspended Solids	219	12	55	5	≤2.20 X Turbidity		219	5	72.8
Dissolved Solids	3741	3715	3544	3733		≤ 750 Ave. ≤1000 Max.	3741	3544	3683
Aluminum (Al)	195	0.21	0.5	0.3			195	0.21	49
Manganese (Mn)	60	7.0	6.2	5.9			60	5.9	19.8
Settleable Solids(ml/l)	1.4	< 0.1	< 0.1	< 0.1			1.4	<0.1	0.43

* Discount these values. Due to highwall slide they represent ground water, not pit water.

TABLE 24
COLONIAL PIT DISCHARGE
WATER ANALYSES TABULATION
SAMPLE LOCATIONS C-3 & C-6

	C-3	C-6				
	9/8	10/13	11/30	Max.	Min.	Ave.
Flow (gpm)	3800	1080	824	3800	824	1901
pH (electrometrically)	7.6	6.8	6.8	7.6	6.8	7.1
M.O. Aklalinity ($CaCO_3$)	228	92.4	50.9	228	50.9	123.7
Free Acidity ($CaCO_3$)	-	-	-	-	-	-
Total Acidity ($CaCO_3$)	8.0	27.2	28.4	28.4	8.0	21.2
Conductivity(25°C)mmhos.	3240	4050	4320	4320	3240	3870
Turbidity (JTU)	240	-	360	360	240	300
Calcium (Ca)	283	405	560	560	283	416
Magnesium (Mg)	175	215	260	260	175	217
Hardness ($CaCO_3$)	1486	1896	2466	2466	1486	1949
Sulfate (SO_4)	2305	2760	3457	3457	2305	2841
Total Iron (Fe)	370	33	44	370	33	149
Ferrous Iron (Fe)	4.36	1.32	32.6	32.6	1.32	12.76
Total Solids	3960	4482	5589	5589	3960	4677
Suspended Solids	219	54	112	219	54	128.3
Dissolved Solids	3741	4428	5477	5477	3741	4549
Aluminum (Al)	195	0.13	0.33	195	0.13	65.2
Manganese (Mn)	60	19	17	60	17	32
Settleable Solids (ml/l)	1.4	<0.1	0.5	1.4	<0.1	0.95

However, on the basis of the water quality at the present point of discharge, this effluent would not require additional treatment. The alkaline nature of the final effluent discharge, along with the alkaline condition of the spoil material at the Colonial site, generally do not lend themselves to a suitable demonstration of a hydrated lime treatment scheme.

As previously mentioned, all spoil material is generally low in nitrogen, which is required in rather large amounts for plant growth. As an alternative to hydrated lime neutralization followed by irrigation, it is suggested that the Colonial site could be utilized to demonstrate the benefits derived from irrigation supplemented with ammonium nitrate as opposed to straight irrigation. A third plot (non-irrigated) could also be utilized to verify the effectiveness of the two proposed test areas.

The survey work, weir structure design and preliminary engineering necessary for the development of such a system has been completed at the Colonial site. The required irrigation water could be picked up at any point in the present drainage system and could effectively reduce the discharge of total dissolved solids into the receiving stream while enhancing the growth of vegetative cover. This treatment scheme has been suggested, but not recommended, as an alternative to abandonment of the Colonial site.

Preliminary Design

Investigations were made at both the Colonial and Vogue sites for the purpose of determining the moisture holding and transmitting properties of the spoil material. The results of these investigations are shown below.

Site	Sample	Saturated Hydraulic Conductivity Inches/Hour	Moisture Holding Capacity Inches/Foot
Vogue	1	.521	1.13
	2	.142	1.35
	3	.235	1.46
Colonial	1	.069	0.84
	2	.295	1.83
	3	.064	1.49

From these figures an irrigation rate of about 0.20 inches per hour was decided upon.

Several alternate methods of irrigation were considered for each area. All are based on applying 1.5 inches of water at each irrigation with a seven (7) day frequency of irrigation. The systems have the ability of applying 0.6 inches at each irrigation with a frequency of three (3) days. This lower application at three (3) day intervals would be used during the germination and early growth periods of the vegetation. It was assumed that the vegetation during the summer would require about 0.25 inches of water per day.

Vogue Site

Four irrigation systems were considered for the Vogue site, namely:

High Pressure Nozzle System (Solid Set)
Big Gun System
Furrow Irrigation (Hand Move)
Furrow Irrigation (Solid Set)

A hand moved high pressure nozzle system was not considered since very little pipe savings could be affected with the long narrow site being irrigated.

High Pressure Nozzle System

Of the four systems considered, the high pressure nozzle system appeared to best lend itself to the conditions applicable at the Vogue site. It consists of one lateral running the entire length of the site with Rainbird 80 EW TNT sprinklers (or equivalent) spaced at 150 feet on the lateral. Each nozzle puts out 84 gpm over a diameter of 220 feet. This sprinkler selection kept the application rate low. Twelve sprinklers are used at one time and are hand moved. The nozzles should be set on an 18-inch riser and used in conjunction with Webstermatic (or equivalent) quick connect fittings allowing for rapid moving.

The time required for applying 1.5 inches of water is 7.5 hours for each setting. With 60 sprinkler locations, 5 days would be required to cover the fields. During emergence 0.6 inches of water can be applied in 2-1/2 days operating only eight hours a day. A time clock shut-off could be used to increase the operating time to 16 hours a day without increasing the operator time.

The actual operator time required will be less than two hours per day.

Big Gun System

This system is considered the best alternate to the high pressure (solid set) system. It consists of the use of two Rainbird 205 part circle water guns (or equivalent) mounted on a trailer and an 8-inch main distribution line running the length of the entire field. Tees would be located at 200 foot intervals on the main for connecting the water guns. The water guns would be moved with a tractor or similar vehicle twice each day. Approximately one hour would be required daily for moving the guns. Other labor requirements are nil.

The possibility exists of getting the vehicle stuck in the wet field before grass is firmly established. For this reason self-propelled guns were considered; however, these required the use of expensive 4-inch rubber hose. Consultation with an equipment manufacturer revealed that the probability of frequent puncture of the hose was great on the rocky fields. Therefore, the self-propelled system is not recommended. The possibility of getting stuck while pulling the water guns is another reason that this system was not recommended.

In order to keep the application rates below 0.2 inches per hour, the guns would have to be cycled on and off on a 15-minute cycle. This requires the use of a timer and motor operated valve arrangement such that surges are prevented. The On-Off cycles are not as desirable as continuous operation.

Operator time for this system is less than one hour per day.

Furrow Irrigation (Hand Move)

This system is the second alternate to the high pressure nozzle solid set system. It involves the use of a 5-inch distribution line running the length of the fields, fourteen 5-inch gated pipe lateral lines for distributing water to the furrows and 6-inch by 12-inch furrows spaced 40 inches plowed on the contour. Deeper furrows would cause excessive ponding problems during rainfall periods. A valve located at the lateral would reduce the pressure from the mainline to the lateral lines. The laterals can be hand moved to keep the cost down.

This furrow size provides for an average application of 0.6 inches each flooding. With the expected evaporation rate for that area of 0.2 to 0.3 inches per day, the field must be covered at least every three days. Operating eight hours per day, this requires 24 furrows to be irrigated at one time. Approximately 1,400 furrows would be needed.

One operator cannot watch 24 furrows at one time while moving laterals and prevent the furrow from overtopping; thus, two full-time operators would be required. Electric valving could be installed to automatically shut the gates on the pipe; however, the apparatus to do the job is still in the experimental stage and is not commercially available.

The installation of the system would require considerable surveying time. In order to adequately irrigate the areas, it is imperative that the furrows be exactly on the contour. As a minimum, every fourth furrow should be staked with stakes spaced 20 feet along the furrow. The furrows can be constructed with a conventional grader with the blade set at an angle. This is considerably more rugged than conventional agricultural plows.

The problems of ponding of water in the level furrows during periods of excessive rainfall will cause difficulty in obtaining vegetation in the furrow bottoms and will present a mosquito problem. Because of this ponding problem, the high labor costs during operation and the high equipment and installation cost, this system was not recommended.

Furrow irrigation is normally cheaper than sprinkler irrigation; however, the rows used with furrow irrigation are normally longer than 2,000 feet, whereas the row lengths in these sites range from 50 feet to 400 feet. This requires a large number of distribution lines which increase the costs. The variable slopes require a high installation cost compared to a flatter terrain.

Furrow Irrigation (Solid Set)

This system is the same as the hand move system, except that enough gated pipe is purchased to permanently set all laterals rather than hand move laterals. This reduces the labor required. At least one full-time operator would still be required.

This system is not recommended due to the high costs and the ponding problem.

Colonial Site

Three irrigation systems were considered for this location, namely:

High Pressure Nozzles (Solid Set)
Big Gun System
High Pressure Nozzles (Hand Move)

Again, the high pressure nozzle system best lends itself to the conditions applicable at the Colonial site.

High Pressure Nozzles (Solid Set)

This system has a low labor requirement. It requires that 19 sprinklers be snapped out of the laterals and moved to a new position each day. One man could easily accomplish this in less than an hour. The sprinklers recommended in this system are Rainbird 80 EW TNT with 9/16-inch nozzles. These sprinklers put out 84 gpm on a 220 foot diameter circle. The system consists of a main running across the middle of the area with laterals off each site of the main line. The sprinklers are spaced on a 150 foot x 150 foot triangular pattern.

This system must be operated about 5.5 hours per day for 6 days to cover the entire area (based on irrigation of the total allotted area - 60 acres). With one hour per day allowed to move the sprinklers, 39 hours per week are required. During germination and early growth of the vegetation, the system would be operated on a 3-day frequency or less by applying less water at each irrigation.

Big Gun System

This system has a low labor requirement. It requires that 10 trailer-mounted guns be moved each day. The guns recommended are Rainbow 205 part circle rain guns with

1-3/8-inch ring orifices. These guns put out 382 gpm on a 410 foot diameter circle. The guns would be set every 180 feet along the laterals. The laterals would be spaced at 220 foot intervals across the area. Six laterals would be required.

Because of the high discharge of these guns, they would have to be cycled to operate only one-half of the time. Thus, five guns would be operating at all times. A 15-minute cycle controlled by an electric timer and motor operated valve are recommended.

Part circle sprinklers are required so that the trailer-mounted nozzles can be moved without operating the moving vehicle on recently irrigated ground.

With this system operating as described above, about 10.5 hours are required to get 1.5 inches of water on at 0.19 inches per hour. This would make it necessary to have a time clock on the pump to shut it down so that a man would not be required to be on the site for the entire 10.5 hours.

There are about 60 gun locations requiring six days to cover the entire area. The frequency of coverage can be decreased to three days or less by applying less water. This would be desirable during germination and early growth of the vegetation.

High Pressure Nozzles (Hand Move)

This system is similar to the high pressure nozzle solid set system, except in addition to moving the sprinklers the lateral pipe also must be moved. This would require considerably more labor but would greatly reduce the cost of the system. The application rates and times would be the same as for the high pressure nozzle solid set system. The time required to move the system would be approximately 8.5 man-hours. This would have to be accomplished daily.

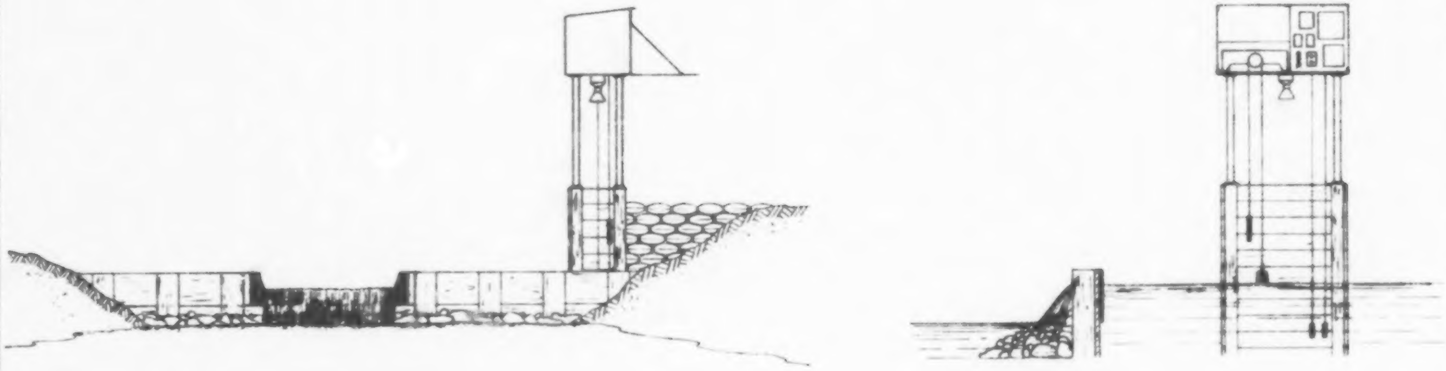
Surveillance Facilities

An important part of the demonstration project is the documentation of the effectiveness of the control measures being demonstrated. In the proposed project, measurement of the quality and quantity of the drainage from the pit area and the chemistry of the spoil would show both the effect of discharge of treated effluent to the stream and the effect of discharge to the irrigation system on the spoil area. In the latter case, runoff from the irrigated and non-irrigated areas should be intercepted before entering a stream course and the quality and quantity monitored. This would provide for a correlation of the effects of rapid establishment of vegetative cover with respect to sparsely vegetated spoil banks.

After the land is formed for irrigation, a specific number of selected, marked sites should be established as sample locations. These should be sampled prior to liming and fertilizing and after the application of lime and fertilizer. Subsequently, they should be sampled periodically to determine the effect of the treated irrigation water on the soil properties. In addition, observations on plant growth at each sampling site should be made in an effort to correlate the vegetative growth with the soil chemical characteristics.

The locations of the proposed stream monitor stations at the Vogue mine site are indicated in Figure 6. The monitor equipment for each station would be housed in a weatherproof enclosure which will be mounted above a stilling well located just upstream from the weir structure. A typical stream weir structure and monitor station is illustrated in Figure 11. The design for the monitor station is illustrated in Figure 12, General Arrangement, and Figure 13, Schematic Diagram.

Each monitor station would continuously record conductivity, pH and flow. Since continuous measurement of all parameters of interest would not be practical, measurement of the foregoing would, when correlated with spot sampling and laboratory analysis, allow reasonable estimates of the remaining parameters during the interval between samples. Samples should be taken on a monthly basis at each of the indicated stations for laboratory analysis for items such as pH, iron, sulfate, turbidity, chloride, calcium, magnesium, acidity, alkalinity, dissolved solids, suspended solids, settleable solids, manganese, conductivity and aluminum. The monitoring program should begin following the Feasibility Study and continue for the duration of the demonstration project (approximately two years).

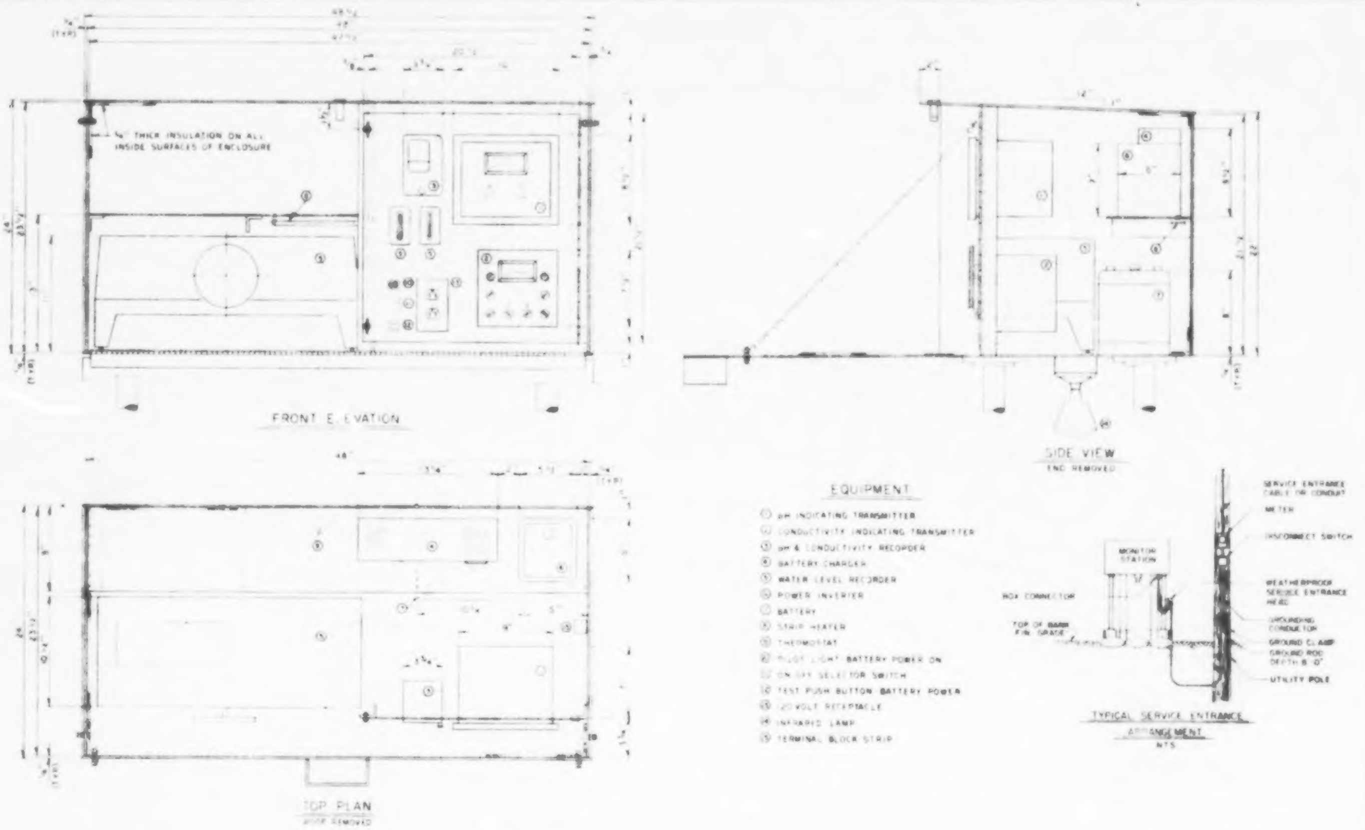


VIEW LOOKING UPSTREAM

VIEW AT OPERATOR STATION

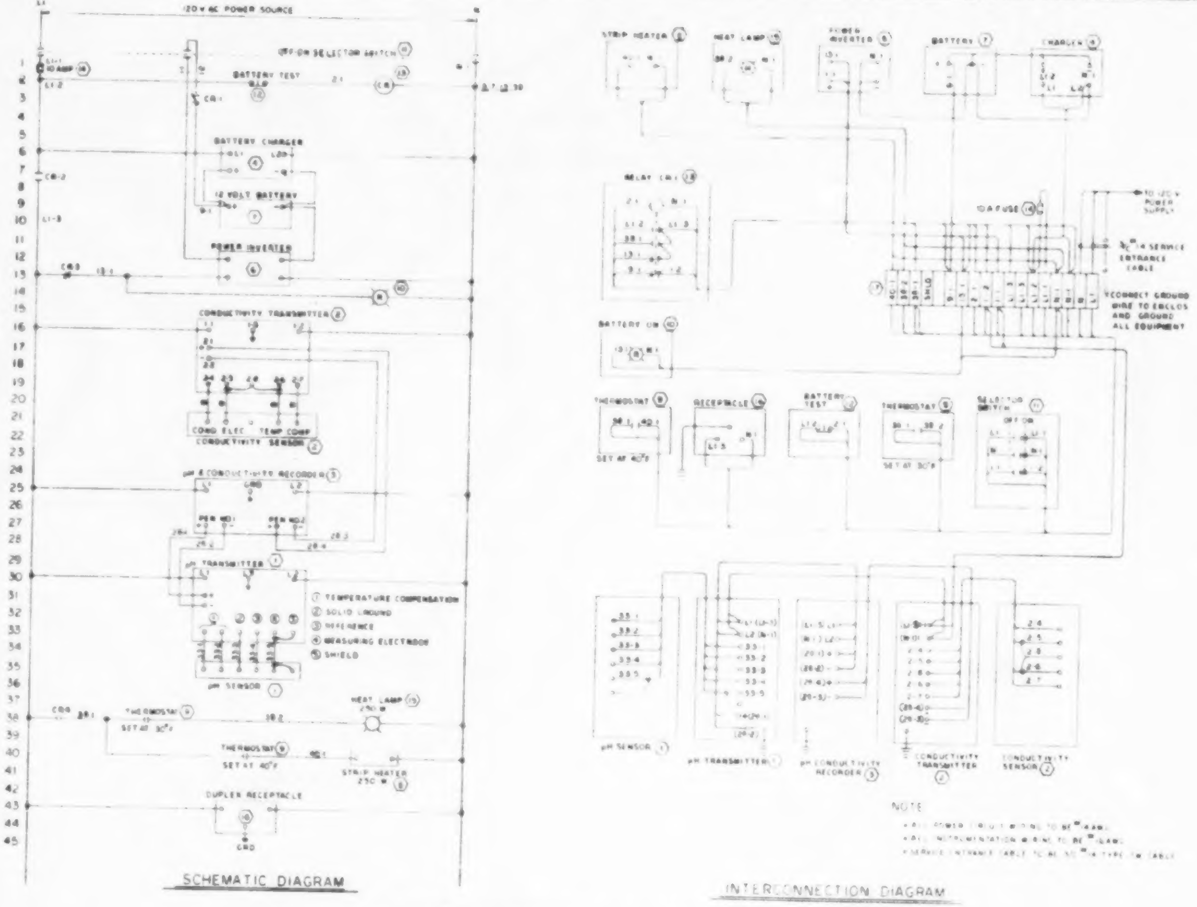
TYPICAL WEIR STRUCTURE AND MONITOR STATION

FIGURE 11


1/4" THICK INSULATION ON ALL INSIDE SURFACES OF ENCLOSURE
FRONT ELEVATION
SIDE VIEW
END REMOVED
TOP PLAN
ROOF REMOVED
EQUIPMENT
① pH INDICATING TRANSMITTER
② CONDUCTIVITY INDICATING TRANSMITTER
③ pH & CONDUCTIVITY RECORDER
④ BATTERY CHARGER
⑤ WATER LEVEL RECORDER
⑥ POWER INVERTER
⑦ BATTERY
⑧ STRIP HEATER
⑨ THERMOSTAT
⑩ PILOT LIGHT BATTERY POWER ON
⑪ ON OFF SELECTOR SWITCH
⑫ TEST PUSH BUTTON BATTERY POWER
⑬ 120 VOLT RECEPTACLE
⑭ INFRARED LAMP
⑮ TERMINAL BLOCK STRIP
MONITOR STATION
BOX CONNECTOR
TOP OF BANK FIN. GRADE
SERVICE ENTRANCE CABLE OR CONDUIT
METER
DISCONNECT SWITCH
WEATHERPROOF SERVICE ENTRANCE HEAD
GROUNDING CONDUCTOR
GROUND CLAMP
GROUND ROD DEPTH 8'-0"
UTILITY POLE
TYPICAL SERVICE ENTRANCE ARRANGEMENT
NTS

MONITOR STATION - GENERAL ARRANGEMENT

FIGURE 12


120 V AC POWER SOURCE
OFF-ON SELECTOR SWITCH
10 AMP
BATTERY TEST
BATTERY CHARGER
12 VOLT BATTERY
POWER INVERTER
CONDUCTIVITY TRANSMITTER
COND ELEC
TEMP COMP
CONDUCTIVITY SENSOR
pH & CONDUCTIVITY RECORDER
PEN NO1
PEN NO2
pH TRANSMITTER
① TEMPERATURE COMPENSATION
② SOLID GROUND
③ REFERENCE
④ MEASURING ELECTRODE
⑤ SHIELD
pH SENSOR
THERMOSTAT
SET AT 30°F
HEAT LAMP
250 W
THERMOSTAT
SET AT 40°F
STRIP HEATER
250 W
DUPLEX RECEPTACLE
GRD
SCHEMATIC DIAGRAM
STRIP HEATER
HEAT LAMP
POWER INVERTER
BATTERY
CHARGER
RELAY CR1
10 A FUSE
TO 120 V POWER SUPPLY
SERVICE ENTRANCE CABLE
CONNECT GROUND WIRE TO ENCLOS AND GROUND ALL EQUIPMENT
BATTERY ON
THERMOSTAT
SET AT 40°F
RECEPTACLE
BATTERY TEST
THERMOSTAT
SET AT 30°F
SELECTOR SWITCH
OFF ON
pH SENSOR
pH TRANSMITTER
pH CONDUCTIVITY RECORDER
CONDUCTIVITY TRANSMITTER
CONDUCTIVITY SENSOR
NOTE
INTERCONNECTION DIAGRAM

MONITOR STATION - SCHEMATIC & INTERCONNECTION DIAGRAM

FIGURE 13

In addition to the foregoing stream monitoring stations, a similar station should be located on the discharge of the treatment facility.

Monitor stations would operate from a primary 120 volt AC source. In the event of a power failure of this primary system, a standby battery power source would be automatically energized. This battery circuit has provisions for testing during routine service inspections.

The battery circuit will function without interruption and the operation of monitoring instrumentation would not be adversely affected. In order to eliminate excessive drain on the battery, the heat lamp and strip heater would not operate on the battery circuit. The battery has the capability of powering the instruments continuously for a period of approximately 20 hours. In the event data recording would be acceptable on a cycled sequence, 2 minutes every 15 minutes, the battery would have the capability of providing power for a period of approximately 6 days. When this circuit is operating from the primary source, the battery charger will charge the battery to its full capacity and then shut off automatically.

When the primary power is restored, the power and control functions are automatically switched back to this source.

The specifications developed for the enclosure fabrications, station assembly, station installation and weir structure construction are included in the Appendices of this report.

Schedule of Design and Construction

The project schedule requires that the engineering phase to be completed and approved prior to the initiation of any construction activities.

A schedule identifying the procurement and construction tasks has been developed and is illustrated in Figures 14 and 15.

FIGURE 14
PROCUREMENT & CONSTRUCTION SCHEDULE
VOGUE MINE SITE

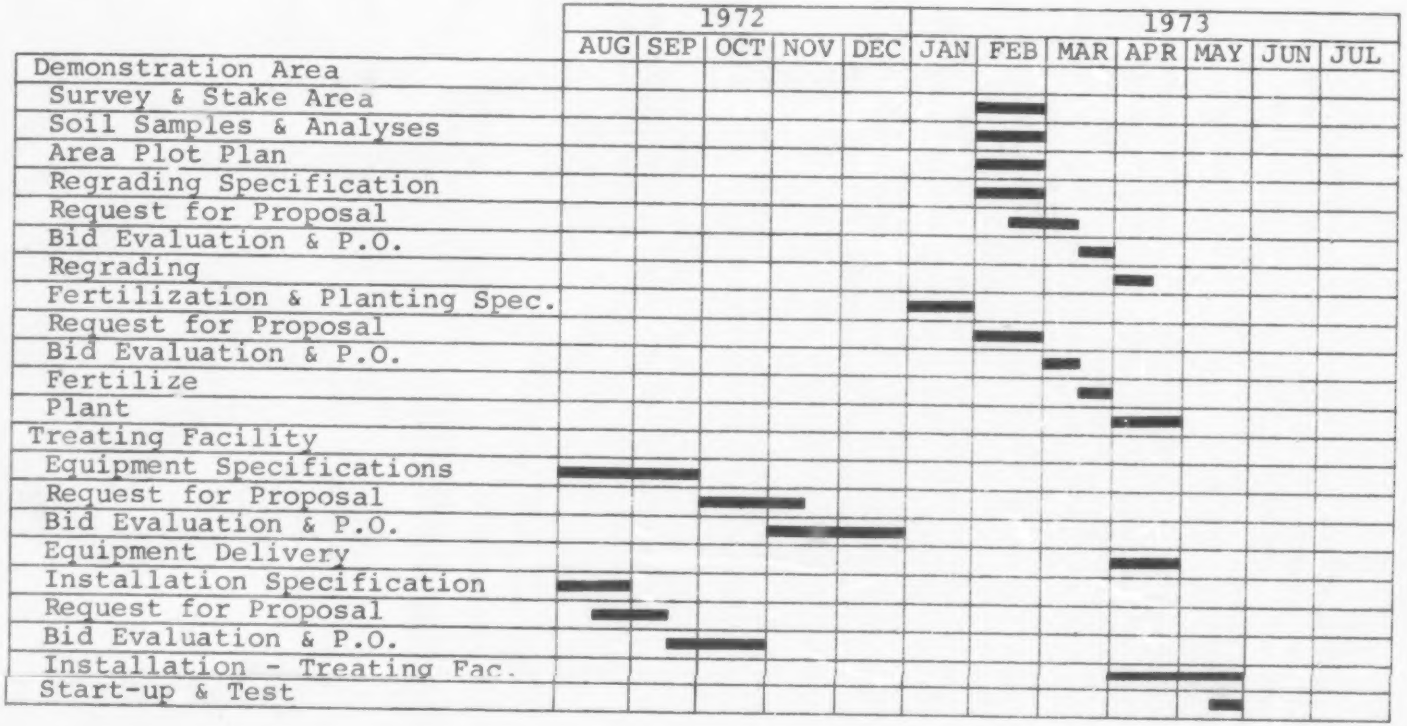
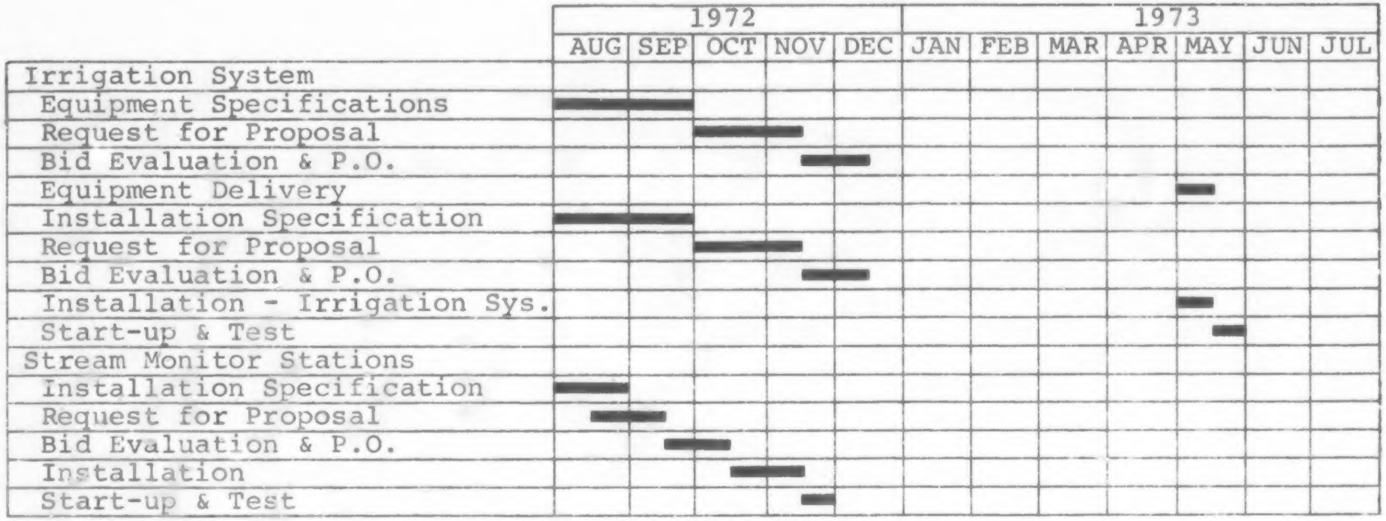


FIGURE 15
ENGINEERING, PROCUREMENT & CONSTRUCTION SCHEDULE
VOGUE MINE SITE



The schedule for the remaining phases of the Grant, including the reporting schedule is shown in Figure 16.

Collecting and Evaluating Data

The instrumentation required to effectively record the parameters that will document the effectiveness of the control measures proposed in this study are discussed in the Section "Surveillance Facilities" and illustrated in Figures 2 and 8. These are:

Stream Monitor Stations	2
Groundwater Monitor Stations	2
Effluent Monitor Station	1
Irrigation Monitor Station	1
Neutralization Monitor Station	1

In order to maintain a continuous flow of information pertinent to the project, the data handling system as identified in Figure 17 should be initiated as each unit goes "on line".

Emergency Provisions for Failure of Project Facilities

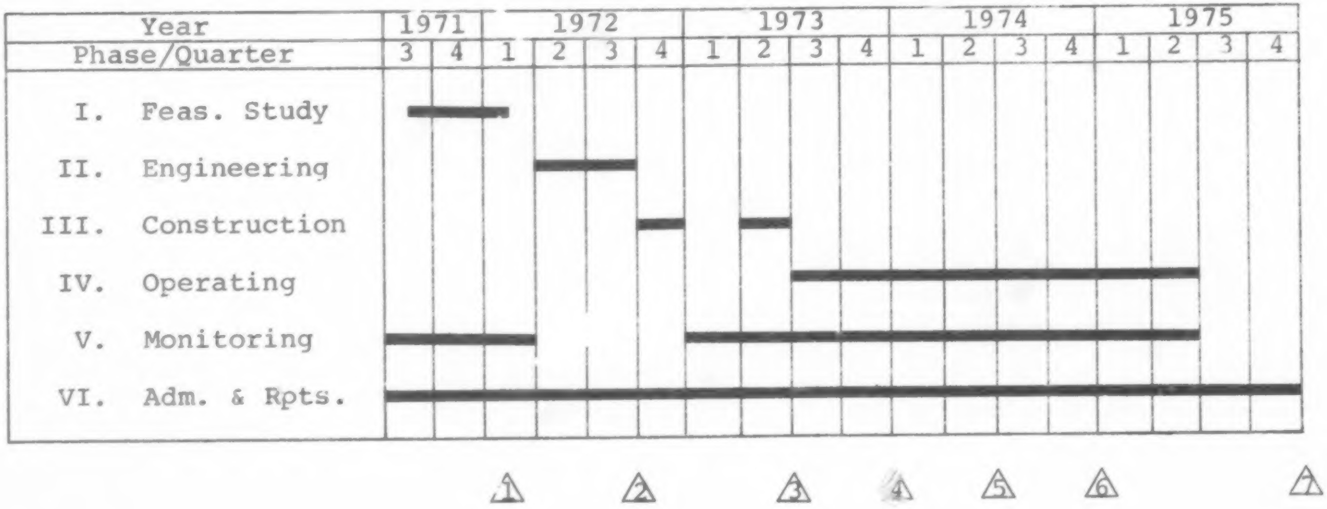
The treatment plant should be so designed that it may operate unmanned during those periods when conditions may require extended or continuous operation. A pH controller would be installed at the effluent line from the mixing tank. In the event of inadequate neutralization or equipment malfunction, the pumping and treatment plant facilities would automatically shut off to insure against the discharge of inadequately treated water.

Capital and Operating Costs

As previously discussed, no acquisition costs will be involved for the purchase of land, minerals or water rights. The use of the demonstration area has been donated by the Peabody Coal Company to the Commonwealth of Kentucky for the duration of the project.

A cost estimate has been prepared for each of the elements of the demonstration facility and are summarized as follows:

FIGURE 16
PROJICT SCHEDULE AND MILESTONES



△1 Feasibility Report
△2 Engineering Report, Construction Report & First Year Report 1
△3 Operating Report 1
△4 Second Year Report 2
△5 Operating Report 2
△6 Operating Report 3
△7 Final Report

FIGURE 17
DATA HANDLING - TASKS AND RESPONSIBILITIES

	TASK	RESPONSIBILITY				FREQUENCY		
		OPER	DR-M	DR-F	CWR	AS REQ'D	WEEK	MONTH
1.	Collect all Strip Charts		X				X	
2.	Read Strip Charts & Record on Tabular Format		X				X	
3.	Transmit Data to Frankfort Office		X				X	
4.	Collect Stream Samples		X					X
5.	Collect Irrigation Samples	X					X	
6.	Collect Effluent Samples	X					X ①	X
7.	Collect Groundwater Samples	X				X		
8.	Transmit Samples for Analyses		X			X		
9.	Water Analyses				X	X		
10.	Transmit Analyses Report to Frankfort Office				X	X		
11.	Prepare Graphical Presentation & Computer Input Forms			X	X		X	
12.	Prepare Monthly Report & Transmit Data to EPA, Cincinnati			X				X

① Weekly, until facility reaches a steady state condition.

OPER = Plant Operator
DR-M = Division of Reclamation, Madisonville
DR-F = Division of Reclamation, Frankfort
CWR = Cyrus Wm. Rice Division - NUS Corporation

Neutralization Facility		
Floating Transfer Pump	$ 18,796	
Storage Bin, Feeder & Mixing Tank	31,915	
Aeration Pond & Aerator	4,230	
Settling Lagoon & Drainways	15,988	
Effluent Monitor Station	5,250	
Subtotal		$ 76,179
Irrigation System		
Floating Transfer Pump	$ 15,394	
Stationary Booster Pump	5,269	
Irrigation Pipe & Fittings	13,110	
Irrigation Monitor	4,350	
Groundwater Collection Ditch	1,330	
Groundwater Monitors (2)	9,500	
Subtotal		$ 48,953
Diesel Power Plant & Control Trailer	$ 22,717	
Site Preparation & Revegetation	8,188	
Soil Samples	960	
Engineering	31,364	
Subtotal		$ 63,229
Stream Monitor Stations (2)		$ 14,600
TOTAL		$202,961

The costs to operate the demonstration facility for 24 months are estimated to be as follows:

System Operator Salary	$ 21,840	
System Maintenance & Repair	13,120	
Monitor Station Parts & Supplies	1,000	
Limestone	31,200	
Diesel Fuel	13,072	
Water Sample Analyses	12,030	
Subtotal		$ 92,262
Data Handling		$ 15,102
TOTAL		$107,364

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SECTION VII

IMPLEMENTATION AND OPERATING PLAN

The Kentucky Department of Natural Resources, Division of Reclamation, would have full authority and responsibility for the demonstration program. This agency would provide for routine servicing for all recording instruments, maintenance of stream gauging stations and weir structures, and periodic collection of water samples from treatment plant effluents, stream monitor stations, and irrigation test plot runoffs.

The procurement and construction schedules to be implemented during Phase II and Phase III of this project are illustrated in Figures 14 and 15. The complete project schedule and milestones are shown in Figure 16. The construction of the facilities at the Vogue site would extend over a period of three months. Construction bids should be obtained, evaluated and contracts awarded during Phase III. Bids would be based on standard uniform specifications. Contracts should be awarded to the lowest responsible bidder taking into consideration the qualities of the articles to be supplied, their conformity with the specifications, their suitability to the requirements of the Federal Government and the delivery terms. Cyrus Wm. Rice Division - NUS Corporation personnel would provide construction supervision to assist the Division of Reclamation.

The proposed report schedule is shown in Figure 16. The reports would be prepared by Cyrus Wm. Rice Division - NUS Corporation personnel in cooperation with the Division of Reclamation.

Operation of the treatment plant/irrigation system should extend over a two-year period. The facility would be designed to operate on a three shift per day, five day per week basis; the first shift to be operator attended, while the second and third shift, if required, would be by automatic operation. One full-time shift operator would be responsible for the system operation. Division of Reclamation personnel would be responsible for overall operational supervision of the facility with assistance provided by Cyrus Wm. Rice Division - NUS Corporation.

A detailed listing of tasks and responsibilities for the neutralization system, irrigation system and monitor stations is illustrated in Figures 18, 19 and 20.

FIGURE 18
NEUTRALIZATION SYSTEM OPERATION
TASKS AND RESPONSIBILITIES

TASK		RESPONSIBILITY				FREQUENCY				
		OPER	DR-M	DR-F	CWR	AS REQ'D	HOUR	DAY	WEEK	MONTH
1.	Operating & Maintenance Manual				X	X				
2.	Operator Instruction				X	X				
3.	System Start-up	X	X	X	X	X				
4.	Maintain System Operation	X					X			
5.	Check & inspect all mechanical and electrical equipment			X	X					X
	Check & inspect all mechanical and electrical equipment		X						X	
	Check & inspect all mechanical and electrical equipment	X						X		
6.	Record Limestone Usage	X						X		
7.	Reorder Limestone		X			X				
8.	Record Diesel Oil Usage	X						X		
9.	Reorder Diesel Oil		X			X				
10.	Equipment Maintenance		X			X				

OPER = Plant Operator
DR-M = Division of Reclamation, Madisonville
DR-F = Division of Reclamation, Frankfort
CWR = Cyrus Wm. Rice Division - NUS Corporation

FIGURE 19
IRRIGATION SYSTEM OPERATION
TASKS AND RESPONSIBILITIES

		RESPONSIBILITY				FREQUENCY				
	TASK	OPER	DR-M	DR-F	CWR	AS REQ'D	HOUR	DAY	WEEK	MONTH
1.	Operation & Maintenance Manual				X	X				
2.	Operator Instruction				X	X				
3.	System Start-up				X	X				
4.	Irrigation Schedule				X	X				
5.	Set Sprinklers per Schedule	X						X		
6.	Start Irrigation Pumps	X						X		
7.	Check Monitoring Instruments	X					X			
8.	Operating Check of Irrigation Pumps & System	X						X		
9.	Check and Inspect System			X	X					X
10.	Equipment Maintenance		X			X				

OPER = Plant Operator
DR-M = Division of Reclamation, Madisonville
DR-F = Division of Reclamation, Frankfort
CWR = Cyrus Wm. Rice Division - NUS Corporation

FIGURE 20
MONITOR STATIONS
TASKS AND RESPONSIBILITIES

	TASK	RESPONSIBILITY				FREQUENCY			
		OPER	DR-M	DR-F	CWR	AS REQ'D	DAY	WEEK	MONTH
1.	Operation & Maintenance Manual				X	X			
2.	Operator Instruction				X	X			
3.	Unit Start-up				X	X			
4.	Check & Inspect all Stations			X	X				X
	Check & Inspect all Stations		X					X	
5.	Check & Inspect Stream Stations	X					X		
6.	Check & Inspect Effluent Station	X					X		
7.	Check & Inspect Groundwater Stations	X					X		
8.	Check & Inspect Rain Gauge	X					X		

OPER = Plant Operator
DR-M = Division of Reclamation, Madisonville
DR-F = Division of Reclamation, Frankfort
CWR = Cyrus Wm. Rice Division - NUS Corporation

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SECTION VIII

ACKNOWLEDGMENTS

The advice and guidance of Messrs. Robert E. Nickel, David Kirtz, C. C. McCall and Calvin Crabtree of the Kentucky Department of Natural Resources is sincerely appreciated.

Messrs. Herb Fox, Robert Harris, Lee Kelce, James Sandusky, Jim Turner and Howard Williams of the Peabody Coal Company, and Messrs. Carl Sainato, Clifford Rice, James Calhoun and Rupert Kington of the Pittsburg & Midway Coal Mining Company supplied valuable data and technical support during the investigative portion of this study.

Drs. G. W. Thomas, B. J. Barfield and C. T. Haan of the University of Kentucky served as special consultants during the preliminary planning and design of the proposed irrigation systems.

Mr. R. R. Johnson, P.E., Madisonville, Kentucky, served as consultant and provided local surveying and design requirements.

The support of the project by the Office of Research and Monitoring of the Environmental Protection Agency and the help provided by Mr. Ronald D. Hill, the Project Officer, Mr. Elmore C. Grim, Strip Mine Specialist, and Mr. Ernst P. Hall, Chief of the Pollution Control Analysis Branch, is acknowledged with sincere thanks.

The principal investigators on this study were Mr. Frank J. Zaval, Project Engineer, and Mr. John D. Robins, Technical Associate, of the Cyrus Wm. Rice Division - NUS Corporation.

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SECTION IX

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Schwab, G. O., Frevert, R. K., Edminster, T. W., Barnes, K. K., Soil and Water Conservation Engineering, John Wiley and Sons, Inc., New York, 1966.

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SECTION X

GLOSSARY OF TERMS, ABBREVIATIONS AND SYMBOLS

1. Emergence: In reference to plant growth, the period from the germination of the seed until the seedling develops a root system and stands about an inch or so in height.

2. Evaporation: The process by which moisture is returned to the air from a liquid to a gaseous state.

3. Evapo-Transpiration: Loss of water from the soil both by evaporation and by transpiration through the plants growing thereon.

4. Germination: To sprout or develop, to begin to grow, to come into being.

5. Highwall: The unexcavated face of exposed overburden and coal or ore in an area mine or the face or bank on the uphill side of a contour strip mine excavation.

6. Moisture holding capacity: The amount of water a soil can hold that is readily available for use by plants.

7. Orphan area: Lands which were surface mined but not reclaimed; usually refers to pre-law mined areas.

8. Overburden: Any material, consolidated or unconsolidated, that overlies a deposit of useful materials, ores or coal.

9. Pre-law area: Lands surface mined before enactment of the 1966 Surface Mining Laws and Regulations.

10. Reclamation: The reconditioning of the area of land affected by strip mining under a plan approved by the Division of Reclamation.

11. Saturated hydraulic conductivity: The readiness with which a saturated material transmits water.

12. Spoil: The overburden or non-ore material removed in gaining access to the ore or mineral material in surface mining.

13. Transpiration: The process by which water as water vapor is transferred into the atmosphere through the tissues of living plants.

14. Volunteer vegetation: Any vegetal growth that appears that was not artificially seeded.

SECTION XI

APPENDICES

DRAWINGS

DRAWING NO.	TITLE
6218-2A1	Monitor Station General Arrangement
6218-2A2	Monitor Station Enclosure Details
6218-2A3	Vogue Survey Plan - Sheet 1
6218-2A4	Vogue Survey Plan - Sheet 2
6218-4A1	Monitor Station V-1, Weir Arrangement & Details
6218-4A2	Monitor Station V-2, Weir Arrangement & Details
6218-4A3	Monitor Station V-3, Weir Arrangement & Details
6218-4A4	Floating Pump Platform
6218-5A1	Vogue Mine Flow Diagram
6218-5A2	Vogue Mine Plot Plan - Sheet 1
6218-5A3	Vogue Mine Plot Plan - Sheet 2
6218-6A1	Monitor Station Schematic & Interconnection Diagram
6218-2A20	Colonial Survey Plan - Sheet 1
6218-2A21	Colonial Survey Plan - Sheet 2
6218-4A20	Monitor Station C-1, Weir Arrangement & Details
6218-4A21	Monitor Station C-2, Weir Arrangement & Details

DRAWINGS (Cont'd)

DRAWING NO.	TITLE
6218-5A21	Colonial Mine, Plot Plan - Sheet 1
6218-5A22	Colonial Mine, Plot Plan - Sheet 2

FABRICATION SPECIFICATIONS
FOR
MONITOR STATION ENCLOSURE

1.0 Scope of Work

1.1 This specification defines the work to be performed by the Contractor in the fabrication of a monitor station enclosure, utilized in the manufacture of an assembly which can be installed on a prepared support foundation to continuously monitor water quality characteristics of a flowing stream. The work shall be performed in accordance with both the specification and referenced construction drawing.

1.2 The Contractor shall furnish all labor, materials, tools, supplies, supervision, equipment and place of business required to fabricate a monitor station enclosure in accordance with this specification and the construction drawing.

1.3 This specification is written on the basis of fabricating one (1) monitor station enclosure. If by virtue of choice the Purchaser expresses the desire to purchase a multiple quantity of same, each enclosure contracted for shall be built in accordance with these specifications, unless otherwise designated by written instructions from the Purchaser's authorized representative.

1.4 It is obligatory upon the Contractor to confirm with the Purchaser, before proceeding with fabrication, the quantity of enclosures to be provided. This shall be considered corroboration of the contract requirements.

2.0 General Requirements

2.1 The Contractor shall be responsible for verifying the dimensional accuracy of the fabrication details given on the construction drawing before undertaking the fabrication of the enclosure. Such verification shall include agreement with cumulative dimensions, indicated means of fabrication, proper fit of the assembled parts, and the quantity, size and material of the various parts.

2.2 Any discrepancies which may result because of the foregoing review shall be called to the attention of the Purchaser's authorized representative, by the Contractor, before proceeding with the work. Corrections shall be made for same before fabrication commences.

3.0 Construction Drawings

3.1 The fabrication of the monitor station enclosure shall be in accordance with the following construction drawing:

6218-2A2 Monitor Station Enclosure Details

4.0 Materials

4.1 Structural steel and plate utilized in the fabrication of the monitor station enclosure shall conform to the "Standard Specifications for Structural Steel" ASTM Designation A-36, as amended to date.

4.2 All steel plate for fabrication of the enclosure shall be 1/4" thick, unless otherwise specifically noted on the construction drawing.

4.3 Standard equal leg angles 1-1/2" x 1-1/2" x 1/4" shall be used throughout for supports for equipment mounting plates.

4.4 All metal shall be free of defects impairing strength, durability or appearance, of the best commercial quality for the purpose used, have structural properties sufficient to withstand the strains and stresses to which subjected and true to detail, having clean, straight, sharply defined profiles and smooth finished surfaces.

5.0 Workmanship

5.1 Workmanship shall be in accordance with the best standard practice of the trade and performed by mechanics skilled in the type of work required. The work shall be fitted and shop assembled, with all joints and intersections accurately made, tightly fitted and made in true planes.

5.2 Defective workmanship in the shop will not be accepted; and replacement of same to satisfy contract requirements will be at the expense of the Contractor.

5.3 Material incorrectly fabricated which necessitates extra field work shall be the responsibility of the Contractor, who shall bear the entire cost of the correction of shop errors and replacement of material including engineering costs.

6.0 Fabrication

6.1 Except as otherwise specified, the structural steel and plate pieces of the enclosure shall be welded in place throughout. Welds shall be 1/8" fillets, unless otherwise noted, and shall be performed in accordance with the weld symbols noted.

6.2 Welds shall be continuous along the adjoining edges and/or surfaces of mating parts of the monitor station enclosure.

6.3 Surfaces to be welded shall be free of dirt, grease, burrs, loose scale, paint and foreign matter. Welds shall be brushed with wire brushes upon deposition, and shall exhibit uniform section, smoothness of weld metal, feather edges without undercuts or overlays, and freedom from porosity and clinkers.

6.4 In assembling and during welding, the component parts of the assembly being joined shall be held in place by sufficient clamps or other adequate means to keep the parts straight, in close contact, and properly aligned.

6.5 Any welds or parts of welds found to be defective shall be cut with a chisel and replaced with proper workmanship.

6.6 Welds that will be exposed to view upon ultimate installation of the monitor station enclosure shall be ground smooth.

7.0 Painting

7.1 The Contractor shall paint all surfaces of the enclosure upon completion of fabrication. However, painting shall not begin until the surfaces have been inspected, cleaned and are in proper condition to receive the paint specified.

7.2 In preparing surfaces for painting, the Contractor shall be sure that the surfaces are free of grease, dirt, rust and scale. Where a heavy coating of scale may exist, it shall be removed by descaling or wire brushing as necessary.

7.3 The enclosure shall be given the following number and type of coats of paint:

Primer - one (1) coat of red lead-oxide primer (Mobil Chemical Company primer 13-R-54, red, or approved equal).

Finish - two (2) coats of enamel paint (Mobil Chemical Company M & F enamel 20-G-12, cypress green, or approved equal).

7.4 Each coat of paint shall be uniform and of the approved color(s). It shall completely cover, be smooth and free from runs, sags, clogging or excessive flooding. Sufficient time shall be allowed between coats of paint for thorough drying and the enclosure surface will be cleaned and properly prepared before each additional coat is applied.

ASSEMBLY SPECIFICATIONS
FOR
MONITOR STATION

1.0 Scope of Work

1.1 This specification defines the work to be performed by the Contractor in the assembly of a stream monitoring station which shall ultimately be installed on a prepared support foundation to continuously monitor water quality characteristics of a flowing stream. The work shall be performed in accordance with both the specification and referenced construction drawings.

1.2 The Contractor shall furnish all labor, materials, tools, supplies, supervision, equipment and place of business required to assemble a stream monitoring station in accordance with this specification and the construction drawings.

1.3 This specification is written on the basis of fabricating one (1) monitor station assembly. If by virtue of choice the Purchaser expresses the desire to purchase a multiple quantity of same, each enclosure contracted for shall be assembled in accordance with these specifications, unless otherwise designated by written instructions from the Purchaser's authorized representative.

1.4 It is obligatory upon the Contractor to confirm with the Purchaser, before proceeding with fabrication, the quantity of monitor assemblies to be provided. This shall be considered corroboration of the contract requirements and serve as the basis from which additional charges for modifications and/or additional units may be made.

1.5 Each unit provided in accordance with these specifications and the referenced construction drawings shall be considered complete upon:

1.5.1 Assembly of all component parts as designated within the specifications and drawings.

1.5.2 Performance of point to point wiring of component instruments in accordance with the assembly's schematic and interconnection diagram.

1.5.3 Refinishing of all painted surface areas of assembly enclosure which may have become damaged during assembly to restore same to original finished condition.

1.5.4 Replacement of all damaged components of the assembly which may have been damaged during assembly.

1.5.5 Testing of the circuitry of the unit to establish that it is workable and functional in accordance with the unit's schematic and interconnection diagrams.

2.0 General Requirements

2.1 The Purchaser's authorized representative shall provide the Contractor with a blank enclosure and several of the components for the assembly of each monitor station. These items are identified by an asterisk (*) adjacent to their item number in the Bill of Material on construction drawing 6218-6A1, and are designated as "items supplied by Purchaser". Receipt of the foregoing by the Contractor will permit him to carry out the terms of the contractual agreement for the supply of the assemblies designated.

2.2 The Contractor shall complete the assembly of the unit utilizing the component parts as defined by manufacturer and model number in the Bill of Material on the construction drawings. No replacements for the items listed will be accepted, unless specifically designated in writing as a replacement by the Purchaser's authorized representative. Substitute items, initiated by the Contractor, must receive written approval of the Purchaser's authorized representative as an "approved equal" before proceeding with assembly and any changes in mounting holes or arrangement and wiring which are thereby necessitated.

2.3 The Contractor shall be responsible for verifying the location and size of mounting holes in the enclosure for mounting the component parts. If it is found that variances exist between the mounting holes provided and the equipment mounts, the Contractor shall notify the Purchaser's authorized representative of same before proceeding. Upon approval to proceed from the Purchaser's representative, the Contractor shall modify the enclosure to suit and mark a set of construction drawings with the "as built" conditions. Upon completion of the assembly, the "as built" drawings will become the property of the Purchaser.

3.0 Construction Drawings

3.1 The assembly of the monitor station shall be in accordance with the following construction drawings:

6218-2A1	Monitor Station General Arrangement
6218-2A2	Monitor Station Enclosure Details
6218-6A1	Monitor Station Schematic Diagram, Interconnection Diagram and Bill of Material

4.0 Workmanship

4.1 Workmanship shall be in accordance with the best standard practice of the trade involved and performed by mechanics skilled in the type of work required. The work shall be shop assembled with all component items securely fastened to the enclosure housing.

4.2 Defective workmanship in the shop of the assembly will not be accepted; and replacement of same to satisfy contract requirements will be at the expense of the Contractor.

4.3 Component items, improperly mounted or incorrectly wired, which necessitate extra field work shall be the responsibility of the Contractor, who shall bear the entire cost of the correction of shop errors and replacement of material, including engineering costs.

5.0 Assembly

5.1 The Contractor shall apply a 1/4" thick layer of insulating material to all the inside surfaces of the monitor station enclosure provided. The insulating material selected by the Contractor shall be an insulating board or material made from fiberglass, mineral wool, cork or some other material with a low thermal conductivity. It shall serve to minimally protect monitor station instrumentation from the severity of temperature fluctuations with the weather conditions where the unit may be installed and retain heat generated by the unit strip heater during cold weather.

5.2 The Contractor shall install and secure in place, within the enclosure provided, all the equipment listed on the construction drawing Bill of Material. The equipment shall be located in accordance with the construction drawings. Equipment shall be secured with fasteners to suit.

5.3 With all component equipment mounted in place, the Contractor shall wire the equipment, point to point, in accordance with the interconnection wiring diagram and schematic diagram on the construction drawings.

5.4 The Contractor shall test the wiring installed for short circuits, grounds and successful operation in accordance with the intent of the wiring diagrams. Where corrections must be made due to improper connections, the Contractor shall make such corrections at his expense. Where improper circuitry according to the drawings is established, the Contractor can negotiate for additional remuneration to cover the cost of performing same and shall mark prints of the "as built" condition, which become the property of the Purchaser.

6.0 Painting

6.1 Where exterior painted surfaces of the enclosure may have been damaged in the process of assembling the monitor station, the Contractor shall repaint the damaged areas to restore the finished surface(s) to their original state.

6.2 In preparing surfaces for painting, the Contractor shall be sure that surfaces are free of all grease, dirt, rust and scale.

6.3 As necessary, primer and/or finish coats shall be applied to the damaged areas. Paint applied shall match the color and coats originally specified. Paint originally applied to the surfaces was in accordance with the following, unless revised in the contract for fabrication of the unit or per selection of approved equal:

Primer - one (1) coat of red lead-oxide primer (Mobil Chemical Company primer 13-R-54 red)

Finish - two (2) coats of enamel paint (Mobil Chemical Company M & F enamel 20-G-12 cypress green)

The purchaser's authorized representative shall be contacted to determine the applicable paint selections if the finished unit is different in appearance than the foregoing.

7.0 Wiring

7.1 All work, materials and manner of placing material associated with the interconnecting wiring of the monitor station shall be performed in accordance with the latest requirements of the National Electric Code.

7.2 All electrical materials furnished as a part of the work shall be approved by the Underwriters Laboratories, Inc., and shall bear their label of approval.

7.3 All 120 VAC power wiring and grounds shall be single conductor, soft drawn, #12 AWG copper wire with 600 volt insulation, type RHW.

7.4 All low-voltage power and signal circuit wiring shall be single conductor, soft drawn, #16 AWG copper wire with Type RHW (rubber) or Type THW (thermoplastic) insulation.

7.5 All power wiring shall be physically separated from signal wiring within the monitor station enclosure.

7.6 Wiring within the enclosure shall be neat and orderly and, where possible, shall be bound into wiring harnesses with standard harness ties.

7.7 The ends of each interconnecting wire shall be tagged with appropriate wire markers carrying the wire numbers designated on the wiring drawing.

7.8 All wires and/or harnesses shall be held in place within the enclosure by appropriate hangers, clips, etc.

INSTALLATION SPECIFICATIONS
FOR
MONITOR STATION

1.0 Scope of Work

1.1 This specification defines the work to be performed by the Contractor in the field installation of two stream monitoring stations in Muhlenberg County, Kentucky.

1.2 The Contractor shall furnish all labor, materials, tools, supplies, supervision and equipment required to secure a monitor station assembly to an existing support structure at each installation site designated by the Purchaser. Installation shall also include the performance of all required wiring connections to the monitor station from the source of power at the site.

2.0 General Requirements and Provisions

2.1 The Contractor is expected to visit each installation site to ascertain to his own satisfaction the means of access to the site, the type of support structure existing, and the stream conditions under which installation shall be made.

2.2 During installation, stream flow at the site shall not be impaired by the activities of the Contractor.

2.3 The Purchaser shall provide the Contractor with one (1) monitor station assembly for installation at each designated installation site. The Contractor shall be responsible for safely transporting and installing same at the site.

2.4 Each monitor station provided shall be considered an approved operating assembly at the time of installation. It is incumbent upon the Contractor to inspect the conditions of said station assembly upon receipt since any incurred damage or claims of inoperability, upon installation, attributable to Contractor negligence will rest with the Contractor.

2.5 Any damage incurred on the assembly in the conduct of the work which shall require replacement or extensive field repairs to the station shall be the responsibility of the Contractor. The Contractor shall immediately notify the Purchaser of any damage and shall solicit an immediate inspection of same. The Contractor shall be liable for all charges for replacement or repairs required on each damaged station assembly due to negligence of his workmen or inadequate installation procedures.

2.6 Inspection and approval of the completed installation by the Purchaser's Project Engineer shall relieve the Contractor of any liability for damages or claims which may be attributable to work performed in placing the installed station in service. Said work shall not be the responsibility of this Contractor.

2.7 The Purchaser shall provide the Contractor with all necessary maps, descriptions or drawings required to locate the installation sites and all drawings and instructions required to properly connect each installed station to the power supply at the sites.

3.0 Installation

3.1 Station Placement

Installation of each monitor station at the site shall require the following:

3.1.1 Provision of four (4) mounting legs (2" schedule 30 pipe) for the station. Pipe lengths shall be determined to match the finished installation elevation of the station as designated by the Purchaser and installation drawings provided. Both ends of each pipe leg shall be threaded to allow connection of the leg to one of the 2" 150 lb. flat face threaded flanges which are a part of the station assembly. Upon installation of all four (4) legs in a like manner, a 2" 150 lb. flat face threaded flange shall be affixed to the free end of each leg.

3.1.2 With all legs in place, the entire station assembly shall be lifted in place above the existing support posts located in the stream bed. The station shall be carefully lowered upon the posts, being sure that the station legs and support posts are in proper alignment.

3.1.3 Adjustment of the legs and/or flanges to make the station level shall be accomplished before the station is permanently fixed in place.

3.1.4 Upon determination that the station is level, the legs shall be tack welded in place to the existing steel plates affixed to the top of each support post rising from the stream bed. Pipe legs shall be centered, as much as possible, within the circular area of each plate.

3.2 Wiring Connections

3.2.1 Operating power (120 VAC) shall be supplied to the installed station from the power source available at the site.

3.2.2 Power conductors shall be 3/c-No. 14 conductor, soft drawn, copper wire with 600 volt insulation, Type TW.

3.2.3 Power shall be connected to terminals N and L1 (tagged) on the terminal strip mounted inside the station assembly in accordance with Drawing No. 6218-6A1 - Schematic Diagram, Interconnection Diagram and Bill of Material.

3.2.4 Wiring to the station enclosure shall be accomplished through a standard conduit fitting and service entrance fitting.

Wiring from the power source to the station enclosure will be run in rigid steel conduit (1/2").

3.2.5 Conduit shall be run in straight lines with no more than three (3) 90-degree bends per run. The conduit shall be run embedded from the power source to the entrance fitting at the monitor enclosure.

4.0 Workmanship

4.1 Workmanship shall be in accordance with the best standard practice of trades involved and performed by mechanics skilled in the type of work required.

4.2 Materials required to make a complete installation shall be new and of the best grade.

5.0 Applicable Regulations

5.1 The Contractor shall obtain all permits, inspections, etc., which may be required by regulatory agencies having jurisdiction over the work sites.

5.2 All electrical materials used in this work shall be approved by the Underwriters Laboratories, Inc., and shall bear their label of approval.

5.3 All work, materials and manner of placing material shall be in accordance with the latest requirements of the National Electric Code and all municipal laws and ordinances relating to the work.

6.0 Cleanup

6.1 Upon completion of all installation work at the sites, the Contractor shall clear the construction area of all debris and excess materials which may remain.

6.2 The Contractor is responsible for complete removal of the aforementioned from the sites and shall do nothing to despoil the surrounding environment by attempting to burn, bury or dump any such debris or materials.

CONTRACTOR'S SPECIFICATIONS
FOR
CONSTRUCTION OF STREAM GAUGING STATIONS

1.0 Scope of Work

1.1 This specification defines the work to be performed by the Contractor in the construction of two (2) stream gauging stations at two (2) separate locations in Muhlenberg County, Kentucky. The construction of each station shall be in accordance with this specification and the individual station drawings which detail their construction requirements (Section 3.0, Plans and Drawings).

1.2 Construction at the site of each station is defined by an individual plot plan on each construction drawing. Base points and bench marks and base lines for each station have been established at the various sites and all dimensions and elevations shown on the drawings are with reference to them. An assumed elevation of 100'-0" has been established at each site as the key reference point.

1.3 The Contractor shall furnish all labor, materials, tools, supplies, supervision and equipment required to construct and place in proper operating condition the two (2) stream gauging stations defined in the referenced drawings.

2.0 General Requirements

2.1 The Contractor is expected to visit each of the two (2) sites to ascertain to his own satisfaction the means of access to each of the construction sites and the construction conditions encountered at each.

2.2 During construction, the Contractor shall maintain stream flow around the construction area as indicated on the individual station drawings. The Contractor shall erect temporary diversion dams to accomplish same and be vigilant in the prevention of deleterious effects to the immediate environment due to such temporary provisions. The Contractor shall be responsible, upon completion of construction, for restoring each stream bed construction area to a condition essentially as found before construction began.

3.0 Plans and Drawings

3.1 The location of each construction site and the requirements for construction of each of the two (2) stream gauging stations shall be in accordance with the following drawings:

6218-4A1 - Stream Monitoring Station No. V-1, Weir Arrangement and Detail

6218-4A3 - Stream Monitoring Station No. V-3, Weir Arrangement and Detail

4.0 Temporary Construction

4.1 As indicated on each station construction drawing, the Contractor shall temporarily divert stream flow, during construction, by providing and placing all sand bag material as delineated.

4.2 Bags shall be 18" x 28" 18-ounce burlap. Each bag shall be filled with sand (only) and, upon filling, shall be securely sewed shut to prevent loss.

4.3 Sand bags used for temporary structures at one site may be used at another site at the option of the Contractor.

4.4 The Contractor shall note that the quantity of sand bags required in the Bill of Material on the various drawings is only an estimated quantity.

5.0 Excavation

5.1 The Contractor shall provide all excavation, grading and backfilling required for the project.

6.0 Permanent Construction

6.1 The Contractor shall furnish all material and construct the timber weir structures in accordance with the construction drawings.

6.2 Timber

6.2.1 The quality of timber sheeting and piling required shall be in accordance with standards established by the American Society of Testing Materials. All timber materials shall be treated by pressure application of hot creosote, or an approved equivalent treatment agent. Substitution of an equivalent agent shall be approved by the Purchaser's Project Engineer prior to use by the Contractor. Creosote for preservative treatment shall conform to the requirements of ASTM D-390-64, Land and Fresh Water Grades.

6.2.2 The timber piling shall be driven to the specified depth or until practical refusal is encountered before that depth is reached. Any pile exhibiting practical refusal shall be subject to the review and approval of the Purchaser's Project Engineer.

6.2.3 Piling shall be driven true and level and shall be checked for such as they are driven. Desired penetration of the piles shall be accomplished within the following tolerances:

a. Piles shall not be more than 2% out of plumb.

b. Piles shall not be more than 3 inches out of place.

6.2.4 Broken or shattered piles shall not be acceptable. If any pile is misdriven or otherwise unacceptable, the Contractor shall drive an extra pile or piles, at no further expense to the purchaser, to replace the unacceptable pile(s). The Contractor shall be prepared to extract piles which are overdriven or damaged.

6.2.5 Piles shall be cut off at the proper cap elevation and the cut shall be horizontal. Upon establishment of the cap elevation, a finish cut shall be made on each pile so indicated on the construction drawing details. All cut ends shall then be brushed with two coats of hot creosote and one coat of coal tar, or an approved equivalent treatment agent.

6.3 With all piles properly installed and cut ends treated, California redwood sheeting shall be bolted to the piles in accordance with the drawing installation details to complete the weir plate support structure. Sufficient caulking, to prevent seepage, shall be placed between all planks to make the finished construction watertight.

6.4 The Contractor shall place bolts for securing the steel weir plates in the support planks in accordance with the construction drawings. The workmanship shall assure placement of the weir plate in a true and level position.

6.5 Riprap shall be placed against the downstream side of the weir support structure in accordance with the construction drawings to prevent scour.

6.6 The Contractor shall provide and place all bags filled with a mixture of sand and cement as required to construct the permanent structures on either end of the weir structures. The bags shall be 18" x 28" 18-ounce burlap and shall be filled with a mix consisting of one (1) part cement and nine (9) parts well-blended sand. This mix shall be blended (no water is to be used) to prevent channeling when in final position in the stream bed. After filling with the above mix, the bags shall be securely sewed shut to prevent loss of material. The Contractor shall note that the quantity of such bags required in the Bill of Material on the various drawings is an estimated quantity.

7.0 Cleanup

7.1 Upon completion of all the permanent construction at each site, the Contractor shall remove all temporary construction and clear the construction area of all debris and excess materials of construction which may remain.

7.2 The Contractor is responsible for complete removal of the aforementioned from each site and shall do nothing to despoil the surrounding environment by attempting to burn, bury, or dump any such debris or materials.

WP-4-1

Re: WATER QUALITY STANDARDS FOR WATERS OF THE
COMMONWEALTH OF KENTUCKY

Relates to KRS 224.010 to 224.210 and 224.990

Supersedes WP-4

Pursuant to the authority vested in the Water Pollution Control Commission by KRS 224.040, the following regulation is adopted:

Section 1. Prohibitions. No person or group of persons as defined in KRS 224.010 shall cause to be violated any one of the minimum standards in Section 2 or any one of the standards established in Section 3 of this regulation.

Section 2. The following are minimum conditions applicable to all waters of the Commonwealth of Kentucky. All waters of the Commonwealth shall be:

(1) Substantially free from substances attributable to municipal, industrial or other discharges or agricultural practices that will settle to form putrescent sludge deposits;

(2) Free from floating debris, oil, scum and other floating materials attributable to municipal, industrial or other discharges or agricultural practices in amounts sufficient to be unsightly or deleterious;

(3) Free from materials attributable to municipal, industrial or other discharges or agricultural practices producing color, odor or other conditions in such degree as to create a nuisance; and

(4) Free from substances attributable to municipal, industrial or other discharges or agricultural practices in concentrations or combinations which are toxic or harmful to human, animal, plant or aquatic life.

(5) In the standards established by Subsections (1) through (4), every person as defined in KRS 224.010 shall remove from their discharges those substances described in Subsections (1) through (4) to the

lowest practicable level attainable under current technology.

Section 3. Stream use classification. In addition to the minimum conditions set forth in Section 2, the following specific stream use classification shall govern where applicable:

(1) Public water supply and food processing industries. The following criteria are applicable to surface water at the point at which water is withdrawn for use for a public water supply or by a food processing industry.

(a) Bacteria: Coliform group not to exceed 5,000 per 100 ml as a monthly arithmetical average value (either MPN or MF count); nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 20,000 per 100 ml in more than 5 percent of such samples.

(b) Threshold-odor number: After normal treatment to be less than 3.

(c) Dissolved solids: Not to exceed 500 mg/l as a monthly average value, nor exceed 750 mg/l at any time. (Values of specific conductance of 800 and 1,200 micromhos/cm (at 25°C) may be considered equivalent to dissolved solids concentrations of 500 and 750 mg/l.)

(d) Radioactive substances: Gross beta activity not to exceed 1,000 picocuries per liter, (pCi/l), nor shall activity from dissolved Strontium 90 exceed 10 pCi/l, nor shall activity from dissolved alpha emitters exceed 3 pCi/l.

(e) Chemical constituents: Not to exceed the following specified concentrations at any time:

Constituents	Concentration (mg/l)
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium (Hexavalent)	0.05
Cyanide	0.025
Fluoride	1.0
Lead	0.05

Selenium	0.01
Silver	0.05

(2) Industrial water supply. The following criteria are applicable to water at the point at which water is withdrawn for use, either with or without treatment, for industrial cooling and processing (other than food processing) and shall be applicable only within a mixing zone.

(a) pH: Not less than 5.0 nor greater than 9.0 at any time.

(b) Temperature: Not to exceed 95°F at any time.

(c) Dissolved solids: Not to exceed 750 mg/l as a monthly average value, nor exceed 1,000 mg/l at any time. (Values of specific conductance of 1,200 and 1,600 micromhos/cm (at 25°C) may be considered equivalent to dissolved-solids concentrations of 750 and 1,000 mg/l.)

(3) Aquatic life. The following criteria are for evaluation of conditions for the maintenance of well balanced, indigenous fish population. The aquatic use standards shall not apply to areas immediately adjacent to outfalls. Areas immediately adjacent to outfalls shall be as small as possible, be provided for mixing only, and shall not prevent the free passage of fish and drift organisms.

(a) Dissolved oxygen: Concentrations shall average at least 5.0 mg/l per calendar day and shall not be less than 4.0 mg/l at any time or any place outside the mixing zone.

(b) pH: No values below 6.0 nor above 9.0.

(c) Temperature:

(i) Not to exceed 89°F.

(ii) There shall be no abnormal temperature changes that may affect aquatic life unless caused by natural conditions.

(iii) The normal daily and seasonal temperature fluctuations that existed before the addition of heat due to other than natural causes shall be maintained.

(iv) The maximum temperature rise at any time or place above natural temperatures shall not exceed 5°F in streams. In addition, the water temperature for all streams shall not exceed the maximum limits indicated in the following table:

Stream maximum temperature for each month in °F.	
January	50
February	50
March	60
April	70
May	80
June	87
July	89
August	89
September	87
October	78
November	70
December	57

(v) The allowable temperature increase in public water impoundments will be limited to 3°F in the epilimnion if thermal stratification exists. Public water impoundments include all impounded waters of the Commonwealth which are open to the public and used by the public.

(d) Toxic substances: Not to exceed one-tenth of the 96-hour median tolerance limit of fish; where there are substances that are toxic because of their cumulative characteristics other limiting concentrations may be used in specific cases as presently approved by the Federal Environmental Protection Agency, or as later adopted by the Water Pollution Control Commission.

(e) Put-and-take trout streams: The following criteria are applicable to those waters designated by the Commission as put-and-take trout streams:

(i) Dissolved oxygen: Concentrations shall not be less than 6.0 mg/l at any time or any place. Spawning areas (during the spawning season) shall be protected by a minimum DO concentration of 7.0 mg/l.

(ii) Temperature: Stream temperatures shall not be increased artificially above the natural temperature at any time in cold water trout streams.

(4) Recreation: Unless caused by natural conditions, the following criterion shall apply in waters to be used for recreational purposes, (including but not limited to such water-contact activities as swimming and water skiing).

Bacteria: The total coliform level shall not exceed an average 1,000 per 100 ml. Total coliform shall not exceed this number in 20% of the samples in a month, nor exceed 2400/100 ml on any day. If the level of total coliform is exceeded, then a fecal coliform standard shall be used. There shall be a reduction of fecal coliform to such degree that:

(i) During the months of May through October fecal coliform density in the discharge does not exceed 200 per 100 ml as a monthly geometric mean (based on not less than ten samples per month), nor exceed 400 per 100 ml in more than ten percent of the samples examined during a month, and

(ii) During the months of November through April the density does not exceed 1,000 per 100 ml as a monthly geometric mean (based on not less than ten samples per month), nor exceed 2,000 per 100 ml in more than ten percent of the samples examined during a month.

(5) Agricultural: No criteria in addition to the minimum conditions enumerated in Section 2 are proposed for the evaluation of stream quality at the point at which water is withdrawn for agricultural and stock watering use.

Section 4. Multiple uses. One or more uses established in Section 3 may apply to the same waters. The use criteria shall apply to those waters suitable for the use or uses provided in Section 3. In the event there is a conflict between or among the applicable uses, the more stringent use criteria shall apply.

Section 5. Regulation WP-4 is superseded.

Adopted:	July 23, 1971
Filed:	July 23, 1971
Effective:	August 22, 1971

SMR-Rg-11

RE: Water Quality

Relates to KRS 350.090

In order to establish and maintain an effective program for assuring high quality water in the Commonwealth, coal mine operators shall comply with the following requirements:

(1) Treatment

(a) Treatment facilities of sufficient size and number consisting of, but not limited to, collection basins, water retarding structures and silt dams shall be constructed prior to the stripping operation for maintaining a quality of water to specifications in paragraph 1(c) herein. The location of all sediment control facilities shall be indicated on the permit map(s) prior to issuance of the permit.

(b) All treatment facilities ahall be kept in proper working order to maintain those specifications in paragraph 1(c) herein, until the operator can demonstrate that the specifications in paragraph 1(c) herein can be met without such treatment facilities. Records of treatment shall be maintained by the operator on forms furnished by the Division.

(c) The operator shall prevent discharge of drainage, into the waters of the Commonwealth from the area of land affected, the pH of which is less than 6.0 or greater than 9.0 or which contains a concentration of iron in excess of seven (7) milligrams per liter (mg/l). The total alkalinity of the discharge must exceed the total acidity. The discharge shall contain no settleable matter, nor shall it contain suspended matter in excess of 150 Jackson Turbidity Units, except during a precipitation event, which the operator must show to have occurred, in which case 1000 Jackson Turbidity Units may not be exceeded. Suspended matter in parts per million (ppm) may not exceed the Jackson Turbidity Units multiplied by 2.20. Sampling and analyses are to be defined and performed according to Standard Methods for the Examination of Water and Wastewater, Thirteenth

Edition, unless otherwise specified in writing by the Division.

(2) Drainage

(a) Water which might drain into the stripping pit shall be intercepted above the highwall by diversion ditches and conveyed by stable channels (designed so they will not erode) or other means to natural or prepared watercourses unless the Division finds these ditches unnecessary. Such ditches shall be built of sufficient size and grade to handle the runoff resulting from a once in ten (10) year storm event as a minimum.

(b) Intermittent streams in the area of land affected shall be kept free of spoil material for a minimum distance of twenty-five (25) feet on each side of the channel. The Division may grant permission to operate within these limits provided that the natural drainage be conveyed across or under the land affected.

(c) No drainage shall be discharged into underground mine workings. When an underground mine or mine drainage is encountered, the operator shall report this occurrence to the Division and bring any discharge into compliance with paragraph 1(c) herein immediately. Plans must be submitted within five (5) days for permanent control. Upon approval by the Division, the operator shall comply to the plans within thirty (30) days.

(d) Sudden release of large volumes of water onto outer slopes of spoil banks is prohibited.

(e) All drainage originating on the area of land affected must meet the specifications in paragraph 1(c) herein or exit through treatment facilities in accordance with paragraph 1.

(f) The Commission finding that some flexibility is required in the administration of regulations, where special conditions warrant, the director may provide for exceptions to this regulation consistent with the requirements of KRS Chapter 350. All such exceptions shall be presented to the Commission for its approval or rejection.

Definitions

As used in this regulation, certain words are defined as follows:

Area of Land Affected - means the area of land from which overburden is to be or has been removed and upon which the overburden is to be or has been deposited and shall include all lands affected by the construction of new roads or the improvement or use of existing roads other than public roads, to gain access and to haul coal.

Source: Kentucky Revised Statutes Relating to Strip Mining and Reclamation, 1966, Chapter 350.010 (3).

Jackson Turbidity Unit - An arbitrary unit for the optical property of a sample indicating the presence of suspended matter. For preparation of a Standard Jackson Turbidity suspension, see pp. 349-356 of Standard Methods for the Examination of Water and Wastewater, Thirteenth Edition.

Settleable Matter - That matter in a sample that will settle in one (1) hour using the test described in page 539, procedure 1.a, of Standard Methods for the Examination of Water and Wastewater, Thirteenth Edition.

Standard Methods for the Examination of Water and Wastewater, Thirteenth Edition - is believed to represent the best current practice of American water analysts and to be generally applicable in connection with the problems of water purification, sewage disposal and sanitary investigations. The Standard Methods for the Examination of Water and Wastewater, Thirteenth Edition may be obtained from the American Public Health Association, Inc., Publication Office, 1740 Broadway, New York, New York 10019.

224.030 Water Pollution Control Commission; creation; membership; compensation; meetings; officers and employes.

(1) For the purpose of carrying out the provisions of KRS 224.010 to 224.060, 224.080 and 224.100, there is hereby created in the Department of Health a Water Pollution Control Commission.

(2) The commission shall consist of the Commissioner of Health, the Commissioner of Natural Resources, the Attorney General, the Commissioner of the Department of Fish and Wildlife Resources, the Director of Reclamation, the Commissioner of Mines and Minerals, the Commissioner of Commerce, and three citizens of the Commonwealth, to be appointed for terms of four years each by the Governor. One citizen member shall be selected from groups representative of municipalities, one from groups representative of industrial management, and one from either groups representative of municipalities or groups representative of industrial management. Vacancies shall be filled for the unexpired portion of any term in the same manner as an original appointment. Each of the officers of the Commonwealth hereby made a member of the commission may, by written order filed with the secretary of the commission, designate a deputy or other representative in his department to serve in his stead and to perform his duties as a member of the commission in his absence. Such designation shall be deemed temporary only and shall not affect the merit system or retirement rights of any person so designated.

(3) No salary or other compensation shall be allowed any member of the commission but each member may be reimbursed for actual and necessary expenses incurred in the performance of his official duties.

(4) The commission shall select one of its members as chairman and another member as vice-chairman at its first regular meeting in each calendar year. The Commissioner of Health shall be the secretary of the commission, and may employ an executive director and such technical and other personnel as may be required in order to carry out the provisions of KRS 224.010 to 224.060, 224.080 and 224.100 and the policies of the commission, and may define their powers and duties and fix their compensation. During the interim between meetings, the Commissioner of Health may perform in the name of the commission such

functions and duties and may exercise such authority of the commission as the commission may delegate to him, or he may delegate such functions, duties, and authority to the executive director.

(5) The commission may employ, compensate and prescribe the powers and duties of such officers, employes, and consultants, in accordance with the laws of this Commonwealth, as may be necessary to carry out the provisions of KRS 224.010 to 224.050 subject to the approval of the Governor as required in KRS Ch. 12.

(6) The commission shall hold regular meetings at least once in every two months, the time and place of which shall be determined by the commission. Special meetings may be called by the chairman or by three members of the commission by delivery to the office of each member of the commission of a written notice thereof of at least five days in advance of the date of any such meeting. Five members of the commission shall constitute a quorum at any meeting. The commission shall establish bylaws for the conduct of its meeting and shall keep an accurate record of all its proceedings. (1950, c. 69, 4; 1952, c. 127; 1958, c. 148; 1966, c. 21, 1) (Formerly compiled as KRS 220.600)

224.040 Powers and duties of commission.

The Water Pollution Control Commission shall have and be entitled to exercise the following authority, powers and duties:

(1) To exercise general supervision of the administration and enforcement of KRS 224.010 to 224.060, 224.080 or 224.100 and all rules and regulations and orders promulgated thereunder.

(2) To develop a comprehensive program for the prevention, control and abatement of water pollution throughout the Commonwealth.

(3) To advise, consult, and cooperate with other agencies of the Commonwealth, other states and the Federal Government and with affected groups and industries, in the formulation and carrying out of such a program; to accept and administer loans and grants from the Federal Government and from other sources for carrying out any of its functions.

(4) To encourage and conduct studies, investigations, research, experiments and demonstrations and to collect and disseminate information relating to water pollution and the prevention, control and abatement thereof.

(5) To establish, modify or amend, after public hearing, water quality standards for the waters of the Commonwealth according to their particular uses.

(6) To adopt, after hearing, such general rules and regulations pertaining to the prevention, abatement and control of existing or proposed pollution as the commission may deem necessary to the accomplishment of the purposes of KRS 224.010 to 224.060, 224.080 or 224.100.

(7) To adopt, without hearing, rules and regulations with respect to the procedural aspects of hearings, the filing of reports and orders, the issuance of permits and other matters.

(8) To issue, after hearing, orders abating discharges or requiring the adoption of such remedial measures, including the construction of new disposal systems or treatment works or the modification, extension or alteration of existing systems and works, as the

commission may deem necessary or proper; to receive complaints and make investigations in connection with the foregoing.

(9) To examine and pass upon all plans and specifications for, and to inspect the construction of new disposal systems and treatment works, extensions, modifications or additions to new or existing disposal systems or treatment works, and extensions and modifications or additions to factories, manufacturing establishments or business enterprises, the operation of which would cause an increase in the pollutional load of any waters of the Commonwealth.

(10) To issue, continue in effect, revoke, modify or deny, under such conditions as the commission may prescribe, permits for the discharge or deposit of any sewage, industrial wastes or other wastes, into any waters of the Commonwealth, and for the installation and operation of disposal systems and treatment works.

(11) To make investigations or inspections which may be deemed necessary to insure compliance with any of the provisions of KRS 224.010 to 224.060, 224.080 and 224.100 or with any rules, regulations or orders of the commission, or which may be deemed necessary to enable the commission to carry into effect the provisions of KRS 224.010 to 224.060, 224.080 and 224.100.

(12) To institute or cause to be instituted in a court of competent jurisdiction, proceedings to compel compliance with the provisions of KRS 224.010 to 224.060, 224.080 and 224.100 or with the orders of the commission.

(13) To enter at any reasonable time, through any commissioner, assistant, agent or employe, in or upon any public or private property for the purpose of inspecting and investigating conditions relating to pollution or possible pollution of any waters of the Commonwealth, which inspection or investigation will not involve confidential information relating to secret processes or to the economics of operation.

(14) To examine any records or memoranda relating to the operation of any disposal system or treatment works which examination does not involve confidential

information relating to secret processes or to the economics of operation.

(15) To take all action necessary or appropriate to secure to the Commonwealth the benefits of the Federal Water Pollution Control Act (Public Law 845, 80th Congress; 62 Stat. 1155).

(16) To perform such other and further acts as may be necessary, proper or desirable in order to carry out effectively the duties and responsibilities of the commission herein prescribed. (1950, c. 69, 5) (Formerly compiled as KRS 220.610)

350.024 Reclamation Commission; Membership; Meetings; Compensation.

There is hereby created in the Department of Natural Resources a Reclamation Commission, which shall be composed of the Commissioner of Natural Resources, serving as chairman, the Commissioner of Mines and Minerals, and the Director of Reclamation. The members of the Commission, other than the Director of Reclamation, shall receive no compensation for their services on the Commission, but shall be reimbursed for their expenses incurred in performing their functions. The Commission shall meet from time to time on the call of any member, but shall meet at least four times each year.

350.050 Powers of Division.

The Division of Reclamation of the Department of Natural Resources under the supervision of the Commissioner of Natural Resources shall have and exercise the following authority and powers:

(1) To exercise general supervision and administration and enforcement of this chapter and all rules and regulations and orders promulgated thereunder;

(2) To encourage and conduct investigations, research, experiments and demonstrations, and to collect and disseminate information relating to strip mining and reclamation of lands and waters affected by strip mining;

(3) To adopt, without hearing, rules and regulations with respect to the filing of reports, the issuance of permits and other matters of procedure and administration;

(4) To examine and pass upon all plans and specifications submitted by the operator for the method of operation, backfilling, grading and for the reclamation of the area of land affected by his operation;

(5) To make investigations or inspections which may be deemed necessary to insure compliance with any provision of this chapter;

(6) To order, through personnel of the Division, the suspension of any permit for failure to comply with any of the provisions of this chapter or any regulations adopted pursuant thereto;

(7) To order, through personnel of the Division, the stopping of any operation that is started without first having secured a permit as required by this chapter.

350.060 Permit Required; Contents of Application; Map; Fee; Bond.

(1) No operator shall engage in strip mining without having first obtained from the Division a permit designating the area of land affected by the operation. The permit shall authorize the operator to engage in strip mining upon the area of land described in his application for a period of one year from the date of its issuance;

(2) An operator desiring a permit shall file an application which shall state:

(a) The location and area of land to be affected by the operation, with a description of access to the area from the nearest public highways;

(b) The owner or owners of the surface of the area of land to be affected by the permit and the owner or owners of all surface area within five hundred feet of any part of the affected area;

(c) The owner or owners of the coal to be mined;

(d) The source of the applicant's legal right to mine the coal on the land affected by the permit;

(e) The permanent and temporary post office addresses of the applicant;

(f) Whether the applicant or any person, partnership or corporation associated with the applicant holds or has held any other permits under this chapter, and an identification of such permits;

(g) Whether or not the applicant is in compliance with subsection (3) of KRS 350.130 and whether or not every officer, partner, director or any individual owning of record or beneficially (alone or with associates) if known, ten percent or more of any class of stock of the applicant, is subject to any of the provisions of subsection (3) of KRS 350.130 and he shall so certify;

(3) The application for a permit shall be accompanied by two copies of a United States Geological Survey topographic map on which the operator has indicated the location of the operation, the course which would be taken by drainage from the operation to the stream

or streams to which such drainage would normally flow, the name of the applicant and date, and the name of the person who located the operation on the map;

(4) The application for a permit shall be accompanied by two copies of an enlarged United States Geological Survey topographic map meeting the requirements of the subsections below. The map shall:

(a) Be prepared and certified by a professional engineer, registered under the provisions of KRS Chapter 322. The certification shall be in the form as provided in subsection (5) below;

(b) Identify the area to correspond with the application;

(c) Show adjacent deep mining and the boundaries of surface properties and names of owners on the affected area and within five hundred feet of any part of the affected area;

(d) Be of a scale of not less than four hundred feet to the inch and not to exceed six hundred and sixty feet to the inch;

(e) Show the names and locations of all streams, creeks, or other bodies of public water, roads, buildings, cemeteries, oil and gas wells, and utility lines on the area of land affected and within five hundred feet of such area;

(f) Show by appropriate markings the boundaries of the area of land affected, the cropline of the seam or deposit of coal to be mined, and the total number of acres involved in the area of land affected;

(g) Show the date on which the map was prepared, the north point and the quadrangle name;

(h) Show the drainage plan on and away from the area of land affected. Such plan shall indicate the directional flow of water, constructed drainways, natural waterways used for drainage, and the streams or tributaries receiving the discharge;

(5) The certification of the maps by the professional engineer shall read as follows: "I, the undersigned, hereby certify that this map is correct, and shows to the best of my knowledge and belief all the information required by the strip mining laws of this state." The certification shall be signed and notarized. The Division may reject any map as incomplete if its accuracy is not so attested;

(6) In addition to the information and maps required above, each application for a permit shall be accompanied by detailed plans or proposals showing the method of operation, the manner, time and distance for backfilling, grading work and a reclamation plan for the affected area, which proposals shall meet the requirements of this chapter and rules and regulations adopted pursuant thereto;

(7) A basic fee of one hundred and fifty dollars plus thirty-five dollars for each acre or fraction thereof of the area of land to be affected by the operation shall be paid before the permit required herein shall be issued. The operator shall file with the Division a bond payable to the Commonwealth of Kentucky with surety satisfactory to the Division in the penal sum to be determined by the Commission on the recommendation of the Director of not less than two hundred dollars nor more than one thousand dollars for each acre or fraction thereof of the area of land affected, with a minimum bond of two thousand dollars, conditioned upon the faithful performance of the requirements set forth in this chapter and of the rules and regulations of the Commission. In determining the amount of the bond within the above limits, the Commission shall take into consideration the character and nature of the overburden, the future suitable use of the land involved and the cost of backfilling, grading and reclamation to be required. In a particular instance where the circumstances are such as to warrant an exception, the Commission, in its discretion, may reduce the amount of the bond for a particular operation to less than the required minimum.

350.090 Reclamation Plan, Requirements, Approval; Dumping Regulations.

(1) Under the provisions of this chapter and regulations adopted by the Commission, an operator shall prepare and carry out a method of operation, plan of grading and backfilling and a reclamation plan for the area of land affected by his operation. In developing a method of operation, and the plans of backfilling, grading and reclamation, all measures shall be taken to eliminate damages to members of the public, their real and personal property, public roads, streams and all other public property from soil erosion, rolling stones and overburden, water pollution and hazards dangerous to life and property. The plan shall be submitted to the Division and the Division shall notify the applicant by registered mail within twenty working days after receipt of the plans and complete application if it is or is not acceptable. If the plan is not acceptable, the Division shall set forth the reasons for which the plan is not acceptable and it may propose modifications, delete areas or reject the entire plan. Should the applicant disagree with the decision of the Division, he may, by written notice, request a hearing by the Commission. The Commission shall notify the applicant by registered mail within twenty days after the hearing of its decision. Any person aggrieved by a final order of the Commission may appeal through the courts as set forth in KRS 350.032;

(2) In addition to the method of operation, grading, backfilling and reclamation requirements of this chapter and regulations adopted pursuant thereto, the operator, consistent with the directives of subsection (1) above, shall be required to perform the following:

(a) Cover the face of the coal with compacted non-acid bearing and non-toxic materials to a distance of at least four feet above the seam being strip mined or by a permanent water impoundment;

(b) Bury under adequate fill all toxic materials, roof coal, pyritic coal or shale determined by the Division to be acid producing, toxic, or creating a fire hazard;

(c) Seal off, as directed by regulations, any breakthrough of acid water creating a hazard;

(d) Impound, drain or treat all runoff water so as to reduce soil erosion, damage to agricultural lands and pollution of streams and other waters;

(e) Remove or bury all metal, lumber, and other refuse resulting from the operation;

(3) No operator shall throw, dump, pile or permit the dumping, piling or throwing or otherwise placing any overburden, stones, rocks, coal, particles of coal, earth, soil, dirt, debris, trees, wood, logs or any other materials or substances of any kind or nature beyond or outside of the area of land which is now under permit and for which bond has been posted under KRS 350.060 or place such materials herein described in such a way that normal erosion or slides brought about by natural physical causes will permit such materials to go beyond or outside of the area of land which is under permit and for which bond has been posted under KRS 350.060.

350.150 Reclamation Work by Division; Procedure; Acceptance of Federal and Other Funds; Access to Land.

(1) In the reclamation of land affected by strip mining for which it has funds available, the Division may avail itself of any services which may be provided by other state agencies or by agencies of the Federal Government, and may compensate them for such services. The Division may also receive any federal funds, state funds or any other funds for the reclamation of land affected by strip mining. The Division may cause the reclamation work to be done by its own employees or by employees of other governmental agencies, Soil Conservation Districts, or through contracts with qualified persons. Such contracts shall be awarded to the lowest responsible bidder upon competitive bids after reasonable advertisement. The Division and any other agency and any contractor under a contract with the Division shall have the right of access to the land affected to carry out such reclamation.

(2) Any funds available to the Commission and any public works program may be used and expended to reclaim and rehabilitate any lands that have been subjected to strip mining that have not been reclaimed and rehabilitated in accordance with standards set by this chapter or regulations thereunder and which are not covered by bond to guarantee such reclamation;

(3) A person or organization, having qualifications acceptable to the Commission, may post bond or a cash deposit, in a sum determined by the Commission, and assume the liability for carrying out the reclamation plan approved by the Division in areas where the mining operation and any necessary grading and backfilling have been completed. The Division shall then release the bond posted by the operator for such area.

350.152 Acquisition of Land by Commonwealth for Reclamation Purposes.

(1) The Commonwealth, acting by and through its Department of Natural Resources, shall have the power to acquire, either by negotiation or by exercise of the power of eminent domain, land which has been affected or disturbed by strip or auger mining, which now consists of orphan banks or unreclaimed spoil piles, and which in its present state is hazardous or otherwise detrimental to the health and safety of the citizens of the Commonwealth, and for the restoration of which Federal funds have been made available;

(2) Prior to acquiring any land pursuant to Part 3 of this Act, the Department of Natural Resources shall extend to the owners thereof an apportunity to backfill, grade, plant and do other acts of restoration thereon to the same extent and within the same time limits as prescribed by Chapter 350 of the Kentucky Revised Statutes and regulations adopted pursuant thereto. If the owner or owners agree in writing to perform such restoration and, weather permitting, start such restoration within a period of thirty days, the land shall not be acquired by the Commonwealth;

(3) The Department of Natural Resources shall attempt to purchase any land which it has determined should be acquired for the purpose of restoration and which the owners have not agreed to restore as provided in subsection (2) above. In any case where the Department and the owners of the land are unable to agree upon the amount to be paid for the land, the Department may exercise the power of eminent domain against such land by filing a condemnation suit under any procedure as provided in Chapter 416 of the Kentucky Revised Statutes;

(4) The purchase price, in the case of a negotiated acquisition, or the damages as finally determined, in the case of acquisition by condemnation, and the necessary expenses indicental thereto, shall be paid from the Reclamation Fund or appropriations made by the General Assembly for such purposes and appropriations to which Federal funds made available for such purposes have been credited.

350.154 Restoration and Reclamation by Division of Reclamation.

The Division of Reclamation shall have the power to backfill, grade, plant and perform other acts of restoration and reclamation, or contract for the performance of such restoration work, on any lands acquired under Part 3 of this Act, to the extent and subject to such conditions as State or Federal Funds are appropriated and available therefor.

350.156 Restored Land, Transfer to State or Local Agencies.

(1) After restoration of the acquired land, the Department of Natural Resources may, with the approval of the Governor, transfer jurisdiction of such land, or any portion thereof, to any State agency that can best utilize such land for public purposes;

(2) If the retention of such land is determined to be impractical, the Department of Natural Resources may, with the approval of the Governor, sell such land to political subdivisions of the Commonwealth at the cost of acquisition and restoration or public sale to the highest bidder. Such land shall be sold subject to the condition that no strip mining shall be carried on thereon at any time thereafter. The proceeds of any such sale shall be credited to the Reclamation Fund as provided for in Section 37(2) of the Act.

350.163 Division may Accept State and Federal Funds; Reclamation Fund Created.

(1) The Division of Reclamation is authorized and empowered to receive and accept from the Commonwealth or any of its agencies and from Federal agencies appropriations or grants to accomplish the purposes of Part 3 of this Act, and to receive and accept aid or contributions from any source of either money, property, labor or any other things of value, to accomplish the purposes of Part 3 of this Act;

(2) All funds available or paid to the Division of Reclamation under Part 3 of this Act, shall be placed in the State Treasury and credited to a special agency account to be designated as the Reclamation Fund. Any unencumbered and any unexpended balance of this fund at the end of any fiscal year shall not lapse but shall be carried forward for the purposes of Part 3 of this Act until expended or until appropriated by subsequent legislative action.